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WHAT SHOULD BE TAUGHT IN BEGINNING CHEMISTRY.*

BY PROFESSOR F. S. KEDZIE.
Michigan Agricultural College.

By plotting the path of scientific educational progress from earliest times to the present we shall find its movement has been centripetal—from the orbit of the farthest planet to the work of the newest discovered microbe.

Astronomy was an exact science long before chemistry had become distinguishable from charlatanry.

Each progressive step is one by which some fact is developed affording us a clearer insight into our surroundings, giving us more exact knowledge of how we stand related to the soil, atmosphere, and plants. If we compare the few who now pursue astronomical study with the numbers who study matters closer at hand it will show us the mighty change in educational ideas from the past to the present.

Manual training in the high school is here, agriculture even in the common school is coming. We say to ourselves at our clubs and conventions that "we teachers" have accomplished these changes and betterments, but in my opinion it is not the teachers, but the pressing demands of the progressive practical citizens who have forced these alterations in our school and college courses.

While the many changes in the curriculum of study hinted at have been made chemistry itself during the past fifty years has grown from a subject, formerly presented only in the lecture hall in the form of a wonderful and interesting set of lectures and demonstrations accompanied by an appropriate number of explosions, more or less thrilling in character, to a more quiet study

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of simple phenomena in the laboratory by the student himself. The lecture hour is now used mainly as a guide to the student for his individual research later in the laboratory.

What the beginner in chemistry shall first study is not a matter of prime importance, provided it be something with which he can easily and safely experiment and of which he has had previous familiar knowledge. In short, something the beginner "knows all about" but can add to what he knows by your help.

A beginning must be made at some point in the student's horizon of experience, and it seems reasonable that the more familiar the object studied the easier it will be for the beginner to get clear conceptions.

Oxygen, the all pervading, all important element, seems logically to deserve first consideration. For several years past I have led the beginner's attack on the subject by a study of air and the action of the common metals, copper, iron and zinc, when heated upon it.

Difference of point of view may lead many teachers to adopt some other avenue of approach. At the Michigan College of Mines, Dr. Koenig draws his first conclusions from the "lesson of limestone"—comparing physical and chemical properties by illustrative experiments involving study of crystalline form and showing action of calcite on light, action of heat on the powdered mineral and then of acids. His second lesson is drawn from hard wood ashes.

The Greek proverb says "Know thyself," and its suggestion may well be followed in the choice of elements to be studied by the beginner. Taking the elements which compose the mass of organized materials we have C, O, H, N, Cl, S, P, of the non-metallic class, K, Na, Ca, Mg, Mn, Fe, of the metals. Besides these elements necessary to the growth of animals and plants we should also include the balance of the halogen and carbon group and the important useful metals.

One of the most essential truths which should be emphasized from the start and which the teacher himself should fully realize is that chemistry is a practical science and does not exist in any text book, and that its truths are of far greater practical importance outside of the laboratory than they are inside. Bring out strongly the idea that we live our daily lives surrounded by chem-

ical changes unseen and unnoticed by us which all our laboratory study but partially fit us to comprehend and which we are likely never to entirely appreciate. Whenever possible introduce an experiment which touches the daily life. Fresh well water filled into a glass flask with vigorous green leaves placed in bright sunlight will yield enough oxygen in the course of a few hours to cause the spark on a splinter to glow and will give the beginner a glimpse of the work in nature's laboratory. There is more carbon in the atmosphere than in or on the earth's crust. (Eight tons of carbon exist as CO_2 over each acre of the earth's surface.)

Determination of the amount of water of crystallization is a good laboratory exercise, but let the beginner also determine the percent of water in a hard-boiled egg, a piece of bread or a bit of fresh beef. His ideas will be enlarged regarding how much liquid (water) constitute what we commonly speak of as *solid food.*

Make the experiments in lecture room and laboratory simple and direct. Do not use a complicated compound to accomplish what a more simple substance will do. Use hot reduced copper and not alkaline pyrogallol for absorbing O in analysis of air if you have or can rig the proper working apparatus. Derive every conclusion at the start from direct experiment. Do not make a statement and then endeavor to prove the truth of your statement by an experiment—the experiment should come first and the truth be derived by logical steps from the result of the experiment. Progress by this method is slow but sure. The principal advantages gained are:

1. The beginner must understand what are the details of the experiment (training observation).
2. He will reason for himself.
3. He does not learn the truth from a statement made by you, but from an observation made by himself.

The exact order in which the first elements are studied is not of supreme importance, but let there be some logical connection in the order in which you consider the elements which will appeal to the student's mind. Study the more common substances first. As an example we will suppose that we start with air and find that hot metals will take something from the air which causes the metals to gain in weight and the air to lose its power of letting

a candle burn in it. We ask our beginner what other substance next to air is most common—on his replying that water is the substance we then show that water passed over hot metals undergoes a similar change such as the air experienced and that a gas is obtained which does not allow a candle to burn in it, while at the same time the heated metal has gained in weight and appears as though it had been heated in air. The student without difficulty infers that air and water therefore contain a common kind of matter, although he has not yet seen it but simply its effects, and that the gaseous portion not absorbed by the metal from air and that unabsorbed from water while both are colorless and extinguish flame can be easily distinguished by the burning of one gas that, from water, on testing with a taper, and the negative result with the other obtained from air.

You remark, "But all this is no novelty—it is all in print in our text books." True, indeed! This experiment studied by the student from the printed page is of little value—if, however, it is brought before him by actual performance in the lecture room or laboratory it leaves a lasting impression and serves as a sound basis for a beginner's knowledge of the two greatest objects of study—air and water.

The decomposition of water by electrolysis might follow next, then a study of O and H by themselves, including methods for their easy preparation. We then pass to the study of solid common salt and contrast its stability with the unstable compound which yielded O for our experiments, $KClO_3$.

Determining that heat alone will not affect salt—it is dissolved in water and electrolyzed, yielding by double decomposition with the water—Cl—H and NaOH. Next should follow the work with HCl and Cl, (I put HCl before Cl because it is more simply prepared and because the student can appreciate better how salt acting on H_2SO_4 yields HCl gas—after experimenting as he has just done with the action of zinc on H_2SO_4.

I need not detail further how by various natural relationships other elements may be taken up and studied, but progress should always be by stepping stones—not so far removed from each other that the distance will appear to require a jump by the beginner. We *do not* want him to "jump at conclusions" and so aim to have his progress steady and gradual.

Many of the earlier expounders of chemical knowledge filled the first third of their books with matter relating to the general properties of matter, including also chapters on heat, light, electricity, etc., which many of us nowadays require the beginner to have previously studied under the title of "physics." I have found it best to supplement this knowledge by direct physical experiments wherever they have some specially important chemical bearing.

For example, the evolution of heat by chemical combination becomes familiar to the student as he progresses in laboratory work, but that there is a quantitative relation is generally overlooked. A simple experiment which brings the quantitative side prominently forward in the action of HNO_3 on reduced copper saved from the copper oxide reduction experiments.

Using 10 c.c. of HNO_3 in test tube with a thermometer for stirrer I found that dropping into it ½ gram copper gave a rise of 15.4°. Repeating the experiment with a different weight of copper but same quantity of acid I obtained a rise of 31° and ask my beginners how much copper used. (1.006.)

Nothing is more fundamental than Avogadro's hypothesis. For the beginner to comprehend this theory he must know that all gases have the same expansion coefficient.

Prof. Hofmann's apparatus illustrates the general fact of equal expansion of all gases for equal increments of temperature admirably, but does not give us any means of arriving at the figure .00366 (the mathematical coefficient) which we use so often in our calculations. Lately I have tried to determine this constant by such crude apparatus as a glass flask of known capacity plunged into a hot water bath, collecting the gas expanded over the same hot water bath in a graduated tube. Here are two results from my note book: Air .0036, H. .0038.

The idea of concrete molecules of gases and molecular motion the beginner best gains by comparison of their velocities by simple experiments in gaseous diffusion—helped out by the failure of an effort to force the molecules through the porous septum by direct compression. Further knowledge regarding molecules is added to by experiments in weighing the gases under like conditions. We found last term O weighed 15.68—Cl 35.29—N 13.92 times H. Having found the weight of a litre of H and Cl gases we

next weigh HCl gas and ask ourselves how we explain the fact that one litre of Cl plus one litre of H weighs enough to make two litres of HCl gas—splitting of the molecules—the idea of atoms established.

So far I have taken your time in discussing what is largely brought out in the lecture room period. Far more important and much more difficult to carry forward with large classes is the laboratory work. The first two or three laboratory experiments should be performed under the direct personal direction of the teacher but without the use of any guide in the nature of a manual or printed sheets. The beginner will then pay better attention to what he himself is doing and less to what the directions say he should do. He will also be more observant of what is taught him at the lecture or recitation period.

From the first I have felt that carelessness on the part of the student was induced by a course in "phenomena experiments." By this expression I mean that kind of experimentation on the part of the student in which he is to do something and simply note what occurs. You may require him to weigh and measure the various materials which he uses for his experiment, but if at the end of the experiment he does not have a final weighing and calculation he is not much more benefited than if he had been permitted simply to "dose out" his materials.

The past year we have had each beginner devote as much time to experiments of a quantitative character as of the purely phenomenal. Simple open-pan balances costing $8.75 and permitting weighing to a milligram have enabled our students to keep improving in exactness from day to day and see for themselves that they could become more expert.

Introduce plenty of simple mathematical calculations wherever possible, but always have them based on a weight experiment performed by yourself or the student. Do not murder the student's interest by giving him such problems as this to work: "What percent of crystallized blue vitriol may be obtained from water cement of which 150 pounds have the capacity of making an iron bar placed in it weight 250 grams heavier" (Stammer's Chemical Problems, ex. 21, p. 54). How old was Ann? would be of more interest and fully as important.

Give variety to the work by performing yourself occasionally some experiment at the close of the period, announcing that the

conclusions to be drawn from the experiment are to be discussed by the class at the next recitation. Never perform yourself nor have the student perform an experiment which has no scientific nor practical value, but is simply pretty. Lay emphasis on tests for elements and compounds from the beginning. A test for an element is simply one of its distinguishing characteristics and it can be well considered at the time the first study of the element is begun. Nothing is gained by postponing "tests" until qualitative analysis is reached. Always exhibit, if possible, the natural source of the element. A small collection of the more important minerals is of the greatest value for this purpose.

Chemistry cannot be "carried by assault"—like Port Arthur, it must be approached gradually and tunnelled into before even the outworks can be surmounted.

At one time with my classes I spent a good deal of time at the very first "studying the plans of the fortifications" by the use of text books. How we did study and recite definitions of the terms: Atom, molecule, atomic weight, and molecular weight. Using the word "Crith" frequently to help us out. These terms and definitions came first in the text book and so I thought must be first attacked and conquered. Had we any facts of our own derived from experiment from which to draw conclusions illustrating a need for these definitions? No, certainly not—but bye and bye we should need to use these terms, we were assured by the text book writer, and so loaded them in. I am not here to-day to oppose the use of a good text book by the beginner in chemistry, far from it. We beginners need all the help we can get, but at best a text book is only an aid. The object of chemical study should be "the thing" itself to know its properties at first hand, and the beginner becoming accustomed to experiment and reason for himself is enabled to work out his own chemical salvation, *assisted* by the text book and teacher, but *dominated* by neither.

The best text book for the beginner is not the one which tells him all about it, entering into the minutest detail, but rather the one which stimulates him to reason for himself and extend his knowledge beyond book-described experiments.

We cannot know it all. In Ostwald's Conversations on Chemistry (a dialogue which I recommend as being full of good things for instructors to ponder) the master says:

"M: Today we will learn more about oxygen.

"P. I know about it already.

"M. Only very superficially, for you only know a very small part of what is known about it, and what I am going to tell you is only a little part of what is known.

"P. But you know all about it.

"M. No, I do not think there is a single man who really knows all that is known about oxygen."

I have digressed too largely, perhaps, from my assigned topic, but I feel strongly that the good accomplished by chemical study is as much, if not more, due to the mental development and training afforded the beginner as to the greater familiarity with elementary substances and compounds with which he is brought into contact in the course of his study. Few of us who study chemistry ever make it a life specialty. The value of the work to the average student then must lie in the training which it gives and, if properly presented, the better view which he gains of his relation as a living individual to the universe of matter.

NATURE STUDY.

By Robert H. Wolcott.

Associate Professor of Zoology, the University of Nebraska, in charge during the summer of Nature Study work in the University of Missouri.

The majority of teachers who undertake the teaching of nature study have no definite conception as to what it is or what it aims to do. Moreover, the instruction in our universities and colleges is too often such as to give to the teacher no better understanding of the subject. In the majority of cases, realizing that there is a demand for some sort of nature study work, there is offered by one or more members of the faculty what is called "A course in nature study," and under that heading is presented either a diluted form of botany, geology, or zoology, or of all three, as the case may be, leaving the teacher in no better position with regard to her subject than before.

In order to define what, in our opinion, nature study really

should be, it is well to state first the needs which the subject should fill:

1. Beginning as early as possible in the curriculum systematic instruction in observation and in the recording of observation by means of drawing and description should be begun, to be carried forward throughout the course, leading the child gradually up to the sciences which he takes later.

2. There should be some part of the child's school work which will form a connecting link between this work and the rest of his life, which shall counteract any tendency on his part to feel that school is simply a task imposed upon him, and with no particular relationship to his life or the work he expects some day to engage in.

3. Every teacher should in some way or other be able to excite the personal interest of each pupil in his work.

4. And, finally, it is, above all, desirable that the student should get early in the habit of putting his school instruction to some practical use.

To all these needs nature study should respond. It affords the necessary training leading up to the high school sciences; it is a bond of sympathy between teacher and pupil and the only avenue by which many pupils may be led to take an interest in their work; and, above all, it is capable of being carried out of the school room into the home life and play of the child and of impressing him with the practical application which may be made of those things which he learns at school.

From what has been said it is evident that nature study, in our mind, is not a subject; it is not botany, it is not geology, it is not agriculture, nor physical geography, nor any other science. It is a method, a form of training. Call it what you please, we should define nature study as that part of a child's instruction which leads him to inquire into the nature of things, to observe objects and phenomena about him, to learn to communicate to others facts which he discovers for himself, and, later, to draw independent conclusions as to the meaning of these facts.

The writer wishes to emphasize, above all, in this brief discussion the fact that the nature of the subject matter of nature study is not essential; it had best be selected with reference to the tastes and training of the teacher. One may prefer to draw

most of her illustrations and to direct the attention of her pupils mostly to plants, another to animals, another to other kinds of objects or to meteorological or other phenomena. In any case, the subject matter may be utilized in precisely the same way, the same methods may be followed, the same needs met, the same results attained. The key note of the work should be truth—truth in observation, statement and representation of facts observed, and truth in conclusions.

No text book should ever be used. Nature study can only be taught by direct reference to objects and phenomena themselves. It is well for the teacher to have a guide, to have books at her command, but the child should, for a considerable time, not be allowed to use a book at all, and later that which he gets from the book should only be used to corroborate and check the results which he has worked out of his own independent observation. The book should be for reference and not a text. Above all, would we deprecate the type of nature study which spends a large part of the time in reading, poetry, telling stories and filling the child's mind with abstract conceptions rather than leading him to make his own observations. Such nature study is worse than none at all. It wastes time which had better be spent in reading and in lessons in English. It is true that frequently stories may be very effective in exciting among pupils an interest in animals, and a sympathy for them, but such stories should be made part of the reading lessons, not of nature study.

Nature study may be taught, where practicable, by means of excursions into the woods and fields, by means of observations made on the many objects and phenomena which may be brought within the confines of the school house grounds, and upon animals in aquaria and vivaria and plants grown in the windows of the school room. There is no season of the year when an abundance of material may not be found close at hand by the interested and capable teacher. In the case of city schools, if there be no parks or other places where animals and plants may be studied, there will be greenhouses or small market gardens, and, if these are lacking, there is subject matter abundant and interesting enough to furnish ample material for nature study on the very streets of our cities and in the shops and stores which line them. If a teacher can do no better, she can use the physical phenomena

which offer themselves wherever machinery is in operation, the phenomena associated with the weather, those accompanying the change of seasons, and so on. She may bring into the schoolroom living plants and domestic animals. She may secure from a number of stores objects of the most varied character, which may be used for the teaching of the subject of nature study in the way suggested; that is, by direct observation, leading up to delineation, description, comparison and conclusion, without the aid of books, except as above stated. And she will find friends in all directions willing to co-operate in the securing of objects, and gardeners and others ready to furnish information. We would advise that living animals and plants alone be used and no dissection ever attempted. We would also urge most strongly that technicalities be avoided so far as possible, and that no Latin names ever be suggested in the case of either animals or plants. Leave all which is technical for the high school, at least. Even here we believe, as a rule, too much which is technical is given, the tendency being to make the high school course a miniature of that of the college. High school zoology should be the study of living animals and life phenomena, and the learning of biological principles; not the detailed study of anatomy and the dissection of dead animals and, even worse, of ill-smelling and distorted alcoholic material. The average student never gets beyond the high school, and such a student can receive all the scientific training desired, and at the same time such a knowledge of living things and life phenomena as to make the work a source of inspiration and delight throughout life, instead of a horrible memory of unpleasant smells and meaningless parts. To the majority of students who enter the college or university the biological laboratories are places to be shunned instead of being eagerly sought as affording opportunities for studying further the wonderful problem of life.

The author believes that a grading of nature study work is not only possible, but necessary, to accomplish the best results. The child should begin by simple observation; should gradually be taught all methods of representation; should learn how to describe things accurately and gradually to discriminate between what is essential and what is not essential; later led to make comparisons, and, finally, to reach conclusions. Thus having been brought through the lower grades up to the high school, he will have some

foundation as a basis for high school science. The grading of nature study should not be the sort of grading, sometimes suggested, where certain animals and plants and certain subjects of investigation are proposed for one year, a different set for the next year, and so on. But the same objects should be used from year to year, studied in a simple way at first, then in other ways, and with gradually increasing detail. Later their parts should be studied, but not, in the case of animals, by dissection and by comparison with other similar objects, until, finally, after several years, the student should be able to present a monograph on this particular subject of investigation. Any tendency on the part of the child to become tired of the familiar objects may be counteracted by the presentation of different aspects of the subject in successive years—observation only at first, then color work, then description, or by adding to the forms studied from year to year. The writer believes, however, in the study of comparatively few forms and of these thoroughly. The first drawings should be simply outlines, the details to be introduced gradually.

The amount of time spent in nature study should not be great, and the periods preferably brief, while care should be taken that some unanswered questions always go over to the next time. One object should be to secure sustained interest. It is well to have living plants and animals in the schoolroom, where they may be under constant observation. On one occasion a Lincoln, Nebraska, teacher complained to the writer that the children were so interested in the aquaria that they would stay in during recess to watch them, instead of going out for the fresh air and exercise they needed; but, no doubt, time would remove this objection.

Above all, nature study should be practical. Every teacher should endeavor to direct the attention of her pupils to such objects as will give the child information of the character that will be appreciated by the parents and the school board in the vicinity in which her work lies. If in a farming community, lead the work along the lines related to that industry; if in a quarrying or mining region, study the rocks; teach the children to observe and know the domestic and familiar animals, and the trees. If a wise choice of the subject matter be made the teacher has a powerful means of interesting the patrons of the school and the school board in her work. Frequent exhibitions by the class

will convince them of the practical value of the work and will cement the interest when once aroused. School collections are to be recommended, but care should be taken that the collection does not include stuffed birds and mammals. Zoological collecting should be limited largely to that which illustrates the activities of animals, which may themselves be represented by colored pictures or drawings. One teacher in a small town in Nebraska made a decided success by having his class make a collection of woods and by giving an entertainment to the patrons at the close of the year devoted entirely to "Trees."

Finally, I wish to emphasize the fact that no teacher need fear to begin nature study work because she has not sufficient technical scientific knowledge. Enthusiasm for her work and the spirit of nature study will insure success. Let the children themselves, so far as possible, select the objects which interest them. Allow them to make their own observations and draw their own conclusions. The function of the teacher is to bring them into the presence of the objects to be used, suggest things to be looked for when the pupil's imagination fails, and, finally, to act as a critic. She should be very careful not to impart too much information. Bring the child to find out things for himself is possible. She should see that he observes correctly, tells truthfully what he has observed, makes accurate representations and draws right conclusions, and if she be properly prepared for teaching in the grade in which she is giving instruction her judgment should be sufficiently mature to enable her to guard the child from error and so direct his work that the time may be fully and profitably occupied.

Color Photography. A lively revival of interest in color photography is evident in many quarters, and the air is full of stories of the wonderful results obtained by this or that process, including those of Koenig, Lamière, Miethe, Neuhauss, Perscheid, Sczepanik, Slavik, South, Worel and others. The Slavik-Multico process is about to be placed before the American public, and will doubtless receive its due measure of success.—*Photo-era.*

TRIUMPH OF THE METRIC SYSTEM IN THE PHILIPPINES.

By Rufus P. Williams.

Two acts concerning the Philippine Islands in which the metric system plays a prominent part passed the last session of the United States Congress. These were respectively approved February 6 and March 3, 1905. A considerable portion of the first one relates to the acquisition and location of mineral lands, and makes compulsory the use of the metric system and the peso. This act takes the place of the law enacted July 1, 1902, in which feet, miles, hectares, dollars and centavos made a general hodge podge. By the present act the provisions of the act of 1902 respecting mineral lands *"are hereby amended by reducing all measurements therein, whether of distance, area or value, to the metric system, to wit, feet to meters, acres to hectares, miles to kilometers, and also dollars to pesos,"* etc. Other lands were "metricised" by the original law of 1902.

The second act, approved just before the adjournment of Congress, relates to duties on imports into the islands, stating *"That the metrical system of weights and measures at present in use in the Philippine Islands shall be continued,"* following which is a list of dutiable goods (nearly fifty pages in all) designated wholly in metric terms.

Several sections of the act of 1902 relate to coinage. The weights of the *constituent metals* are given in our old-fashioned grains, and follow in this respect the present coinage laws of the United States, enacted in 1828, and this part has not been changed, the peso being the standard of value. The subsidiary and minor coins of the Philippines, as legalized by the act of 1902, are shown in the following table:

SUBSIDIARY SILVER COINS.

Name.	*Weight.*	*Composition.*
50 centavo piece..	192.9 grains troy = 12.5 g.....	silver 90%, copper 10%
20 centavo piece..	77.16 grains troy = 5 g.....	silver 90%, copper 10%
10 centavo piece..	38.58 grains troy = 2.5 g.....	silver 90%, copper 10%

MINOR COINS.

5 centavo piece..	77.16 grains troy = 5 g.....	copper 75%, nickel 25%
1 centavo piece..	80 grains troy.....	copper 95%, tin and zinc 5%
½ centavo piece..	40 grains troy.....	copper 95%, tin and zinc 5%

It will be seen that the 20 centavo piece is a more consistent decimal subdivision than our 25 cent piece. Opponents of the metric system cannot criticise our inconsistency in this as they often have in the silver "quarter." One is reminded, in the *half centavo,* of the half cent of the early days of our Republic. All these coins are the equivalent in composition, as they are in value, of our own corresponding coins, and what specially interests us is that four of the six are metric, and also correspond in weight to ours, as prescribed by acts of May 16, 1866, and February 12, 1873.

We cannot regard these triumphs of the metric system in the "Acts of the Philippines" otherwise than of significant importance. If Uncle Sam's agents find no difficulty in using metric measures in the customs service of the islands, why should they have more trouble in the ports of New York, Boston, or New Orleans? If exports from the islands to the states and from the states to the islands pay duties at the entering port, wherein does the problem of weights and measures differ from that confronting the collector of duties from Germany or France? Unless the influx of manufacturers and traders into the Philippines from the United States and other non-metric countries becomes so great as to drive out the metric system, the acts just passed by the fifty-eighth Congress will not only fasten the system irrevocably on this part of Uncle Sam's domain, but the influence must in time spread to all other parts. Spain and her provinces finally adopted the metric system January 1, 1869. Reversion to an inferior system after so long a time is improbable.

A HIGH SCHOOL MATHEMATICS CLUB.*

By Chas. W. Newhall,
The Shattuck School, Faribault, Minn.

It will be well to explain in starting that the club whose workings are here described was not formed in a public high school, but in Shattuck School, Faribault, Minnesota, a private school for boys. The course in this school, however, is of the same grade as that of a good high school, and the boys are of the

*Read before the Central Association of Science and Mathematics Teachers Nov. 25, 1904.

same age. Work could be done along similar lines, I believe, in any high school, and for that reason secondary school teachers may be interested in our experience.

This Mathematics Club was organized last year, as the result of a desire on the part of some of my students to investigate certain matters connected with mathematics which do not properly find a place in the usual classroom work. It was made up of those members of the Senior class who were taking the college preparatory course in mathematics, numbering about a dozen. As instructor of the class I was chairman, *ex officio*, and the only teacher usually present at the meetings.

The club met every two weeks and devoted itself to a study of the history of mathematics, its famous or interesting problems, mathematical puzzles, fallacies, card tricks, anything, in fact, that was capable of a mathematical solution or explanation, and that promised to be entertaining. A club of boys would not thrive if the meetings were dull. The meetings were held in our classroom at 7:30 on the evening of our weekly holiday (Wednesday), and was supposed to adjourn at 9:00 o'clock. By this time, however, the boys were usually so interested in some discussion as to be willing to remain in session as long as the school regulations would allow. To make it easier for the cadets to spare the time for these meetings, it was understood that no preparation would be expected from them for the next day's lesson in algebra. Each of our evenings was given up to some general subject, and reports were prepared on three or four special topics by as many of the members. This required that each one of the members should work up such a report about every third meeting, or once in six weeks. At each meeting the program was announced for the following one, and thus, those who were to take part had two weeks' time in which to prepare.

We had a small reference library in our recitation room which contained a few books that would yield some information on the subjects in which we were interested. Among the most useful were Ball's, Fink's and Cajori's "Histories of Mathematics," Klein's "Famous Problems in Geometry," Fine's "Number System of Algebra," Ball's "Mathematical Recreations," Heath's series of "Mathematical Monographs," and several of the publications of the Open Court Publishing Co. Besides the books spoken of, we collected perhaps a dozen or twenty popular maga-

zine articles on special topics in our field, as, for example, one by Professor Newcomb on the "Fairyland of Geometry," another on "The Fourth Dimension," etc.

As boys of High School age are new to investigations of the kind that we proposed, it was necessary to help them in the preparation of their reports. They required rather explicit directions and suggestions as to how to treat a given topic, together with reference to two or three of the books available, often by pages. These reports were variously presented by the different students. Some of them could talk extemporaneously from notes, making use of illustrations previously placed on the blackboard. Others preferred to mark certain pages or paragraphs and to read directly from the books what they wished to tell us. Still others, on certain subjects, read carefully written papers, which they were not long in discovering might be submitted to their instructor in English, in lieu of their monthly theme. One student even developed one of his reports into his graduating thesis.

The plan of our meetings was that each of these reports should consume fifteen minutes or so, and be followed by an informal discussion in which any one might ask questions or raise objections, to be met by the one presenting the report. If I could add anything of interest that had not been brought out I did so briefly, but the central idea of the whole scheme was to have the boys do most of the talking. My function was to preside at the meetings, to keep the interest alive and to try to preserve that happy mean of informality which should put the boys at their ease, and yet maintain a certain dignity in our discussions.

Of course, we could consider only such subjects as would be intelligible to secondary school pupils, and these only in an elementary and somewhat superficial way. These students in our senior class had finished plane and solid geometry the year before, and their studies for this year were higher algebra and trigonometry. Our discussions then were restricted to subjects requiring no further acquaintance with mathematics. To give an idea of the various subjects considered in this Mathematics Club, I can do no better than to refer briefly to the programs of our twelve meetings of last year. And I may be pardoned perhaps if I describe the work of one or two of these meetings somewhat in detail in order to show the scope of our investigations.

Our first evening was devoted to the "Early History of

Geometry," the three principal topics being: 1st, "The Beginnings of Geometry"; 2d, "Early Greek Geometry"; 3d, "Golden Age of Greek Geometry." In the first paper was considered the extent of geometrical knowledge among the early nations, the knowledge of astronomy among the Babylonians, and of mensuration and surveying among the Egyptians, the Ahmes value of Pi, and his incorrect statements for the area of the trapezoid and isosceles triangle, the orientation of their temples, the rope stretchers, etc. In the consideration of the "Early Greek Geometry" the marked tendency of the Greek mind toward logic and the appreciation of form was referred to as accounting for this early development among them of geometry as a science. Thales was referred to and the theorems attributed to him with their probable proofs. There was also a brief biography of Pythagoras, a description of his school, and the brotherhood of the Pythagoreans. In the third paper on the "Golden Age of Greek Geometry," Euclid and his work were similarly discussed, his famous "Elements" described and its influence on the modern study of geometry pointed out. Apollonius, Archimedes and perhaps one or two later names were mentioned.

For the material for these papers the boys were referred to Myers' "Ancient History," the histories of mathematics; Smith's "Teaching of Mathematics," Allman's "Greek Geometry from Thales to Euclid," and one or two pamphlets and magazine articles. In order to show the extent of the help thus furnished the students, I will give the outline for the work of our second and third meetings devoted to the "History of Arithmetic and Algebra."

THE HISTORY OF ARITHMETIC AND ALGEBRA.

I. Among the Ancient Nations.
   - *a.* The Egyptians: Ahmes' papyrus, its antiquity, some of its problems, Egyptian fractions.
   - *b.* Greek Arithmetic and Algebra: Not so highly developed as geometry, Greeks interested in theory of numbers rather than calculation (examples). Computations on dust board (expl.) Diophantus and equations.
   - *c.* Roman Arithmetic: No Algebra, arithmetic, only enough for commercial purposes. Use of abacus (illus.).

II. Among the Hindus and Arabs.

a. The Hindus, (sixth and seventh century): Great Computers, arithmetic and algebra their specialty as Geometry for Greeks. Extent of their mathematical knowledge, negative numbers, irrational numbers, zero. Their methods in Arithmetic, false position, inversion. Examples of their poetically stated problems.

b. The Arabs, (eighth to the tenth century): Brief history, great scholars of their time, Arabs as teachers and preservers of Greek and Roman culture, text books writers, the name algebra, Syncopated Algebra.

III. Early European Arithmetic.

General education in the Middle Ages, schools of church and monastery, universities (quadrivium, trivium), Rechenschulen of Hanseatic League.

Examples of four fundamental operations as performed in the Middle Ages; multiplication by Napier's Rods, division by Scratch Method.

IV. Development of Symbolic Algebra.

Algebra originally rhetorical; work expressed fully in words, no symbols.

Syncopated Algebra: abbreviations for the words, still few symbols, Diophantus (330 A.D.), the Arabs.

Symbolic Algebra: Took modern form with Vieta (1600).

Examples of solution of an equation in:

1. Old rhetorical form.
2. Syncopated form.
3. As stated by Vieta.
4. In twentieth century symbols.

Advantages of our symbols.

V. History of Common Symbols of Operation.

Various devices used at different times to express powers, roots, equality, the four fundamental operations, etc., with their origin and dates.

First use of the present symbols.

It is perhaps needless to say that these three meetings on the history of Arithmetic, Algebra and Geometry opened the eyes of the students to the process of gradual development in these sciences. While I am sure that they never enjoyed the study of any history more than this, I am equally sure that it gave them a larger appreciation of the field of mathematics.

Our next two meetings were devoted to the "Famous Problems of Geometry and Their History." Among the problems considered in these two meetings were: The Pythagorean Theorem and Its Proofs; Squaring the Circle; Trisection of an Angle; Duplication of the Cube; Area of a Triangle; Regular Inscribed Polygons.

The following meeting was given up to "Mathematical Puzzles and Fallacies." 1st. "Elementary Numerical Puzzles"; 2d, "Algebraic Fallacies," for example, to prove 1 equals 2, to prove 1 equals 1, to prove 1 greater than 2, etc.; 3d, "Geometrical Fallacies," to prove an obtuse angle equal to a right angle, any triangle is isosceles, part of a line greater than the whole line, and others of the same kind, with which most teachers are familiar. In presenting these puzzles and fallacies the one reading the paper would first propose them to the rest of the members for solution; if they failed to solve the puzzles, or point out the fallacy within a reasonable time, it was then explained to them.

In the next meeting, the seventh, we considered in a similar way, 1st, "Mechanical Puzzles"; 2d, "Card Tricks"; 3d, "Problems on a Chess Board," all of which involved some mathematical principle of number or position. In each case as before, after mystifying his audience, the conjuror was required to give away his trick and to explain the mathematical principle involved.

The program for our eighth meeting was: "Curious Properties of Certain Numbers," with the following special topics: 1st, "Interesting Properties of the Number 9"; 2d, "Perfect Numbers, Divisibility of Numbers, Prime Numbers," etc.; 3d, "Some Theorems in the Theory of Numbers," for example, Fermat's "Last Theorem," Theory of Prime Numbers, etc. In these latter cases we could do little more than state the Theorem and illustrate it by an example.

In our ninth and tenth meetings we took up the subject of "Number Systems and Numerals." As these proved to be, perhaps, the most interesting and suggestive of our meetings to the student members of our club, I will outline them a little more fully.

Number Systems and Numerals.

I. Primitive Systems of Numeration.

First notions of number, counting etc., among animals, among savages.

Gesture symbols, finger reckoning. Early written symbols.

Systems in use among primitive races:

Decimal, Egyptian, Greek, Roman.

Quinary (scale of 5), certain aborigines of America.

Vicigesimal (scale of 20), South American tribes, etc.

Binary (scale of 2), (scale of 11), New Zealand, Patagonian.

II. Development of our Decimal Positional System.

Due to ten fingers. Value of idea of position, of zero, discoveries of the Hindus (date). Advantages of our system (illustrated by multiplying two numbers in Roman notation).

Disadvantages of decimal as compared with duodecimal system.

III. History of Arabic Numerals and Other Number Symbols.

Babylonian, Egyptian, Greek symbols (illustrate). Awkwardness of Roman System.

History of development of so-called Arabic Numerals (Hindu origin).

IV. Problems in Other Systems.

Numbers written in other systems. Multiplication tables in other systems.

Problems in addition, division, etc., with numbers expressed in scale of 9, scale of 5, scale of 2, etc.

Problem in a non-positional system like Greek or Roman, hence necessity for use of abacus.

V. Number Systems of Algebra.

Fractions: Egyptian unit fractions; Babylonian fractions, denominator always 60; Greek and Roman fractions; decimal fractions (recent date).

Irrational Numbers: First use, brief history, etc.

Negative Numbers: The same.

Imaginary Numbers: The same.

The eleventh meeting on "Mathematical Curiosities" contained such topics as:

1st, "The Fatality of Numbers," curious traditions attaching to 3, 7, 9, etc.; 2nd, "Large Numbers"; 3rd, "Magic Squares of Various Kinds and Their Formation."

The twelfth and last meeting was devoted to "Fairyland of Geometry," and considered such questions as, 1st, "Non-Euclidian Space"; 2d, "Infinity"; 3d, "The Fourth Dimension." In such subjects as these we were on rather dangerous ground, but I tried to steer a safe course. Even if the students did not acquire perfectly clear notions about these rather vague matters, I felt that it might be worth while at least to set them thinking.

This was perhaps the most valuable result of the work of our club—it set the boys to thinking. They found that there was more that was interesting in the dry subject of mathematics than they had dreamed. There was not a member of the club but confessed that his attitude toward mathematics had undergone a change since our first meeting. Our investigations were not very profound, to be sure, and will result in no contribution to the sum of mathematical knowledge, but the boys enjoyed the meetings, and, I think, profited by them, and, as these were the two distinct objects of this mathematics club I feel that it proved itself worth while.

IMPORTANT MARCONI INVENTION.

At a lecture before the Royal Institution, London, last week, Mr. William Marconi, the wireless telegraph inventor, announced an invention of great importance to the efficiency of his system. Mr. Marconi said: "I have been able very recently to construct a magnetic detector which will work a relay, enabling messages to be recorded on a tape by the ordinary Wheatstone recorder. The new receiver is far simpler than any yet devised for wireless telegraphy. It requires less attention, and is absolutely reliable. The principal advantage is, however, that the receiving speed is increased from 24 to 100 words a minute."—*Electrical Review.*

A NEGLECTED POINT IN THE TEACHING OF ELEMENTARY DYNAMICS.

By Henry Crew.

Professor of Physics, Northwestern University, Evanston, Ill.

Few words in the English tongue have been made to carry so heavy a burden as the little monosyllable "force." No word is used more loosely or with a greater variety of meanings; yet no word is perhaps more capable of exact definition.

The following difficulty, which relates to this same physical quantity, is one which will appear to many as no difficulty whatever. But, having stumbled over it in my own teaching and having learned by conversation with other teachers that the question was by no means clear to all of them, I offer no further apology for mentioning it here.

Physical science, in so far as it has been reduced to a quantitative basis, is preëminent for its exact terminology. It defines physical quantities in a precise, clear-cut manner and then uses these definitions with rigid consistency.

From Newton to Poincaré inclusive the force acting upon any body at any instant has been defined as the product of the mass of the body multiplied by its acceleration at that instant. In terms of the usual algebraic symbols the defining equation of force is

$$F = m\,a$$

But if this be granted how is one to justify himself in saying that force is required to maintain a constant elastic deformation, where no acceleration of any kind is involved? This is the difficulty alluded to in the title of this note. If, for instance, one takes two ordinary spring balances, one in each hand, hooks them together and stretches them, each will register the amount of the pull. Since, however, no acceleration is present what right has one to infer the existence of a force? The patent reply is that "action and reaction are equal and opposite." Quite true: but if we are to accept mass-acceleration as the measure of force, what evidence have we that either of these forces—action or reaction—is present? Plainly we must either abandon mass-acceleration as the criterion of force or we must conclude that no force is acting in the case of the stretched spring. This suggests at once the solution of the difficulty, namely, mass-acceleration is the definition and measure, *but not the criterion*, of force.

If, then, forces may exist where the accelerations are all zero, it is evident that the student must have a bridge connecting these two groups of forces (viz: the so-called effective forces and other forces) so that he may employ the same unit, the dyne, whether working with one group or another. Some text books attempt to furnish such a bridge by attaching a mass to the lower end of a vertical spiral spring and using the weight of the suspended mass as a measure of the force required to elongate the spring. But here again there is no acceleration. The reply is, of course, that an acceleration *would* occur if the mass were allowed to fall freely. But when the mass is once detached the problem immediately becomes dynamical and hence very different from the statical solution offered.

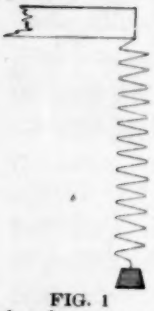


FIG. 1

The universal validity of our accepted definition of force should be illustrated by a direct and experimental connection between the force required to maintain a constant elastic strain and the force required to maintain a constant acceleration in a given mass. Such an experiment is the following: Take an ordinary

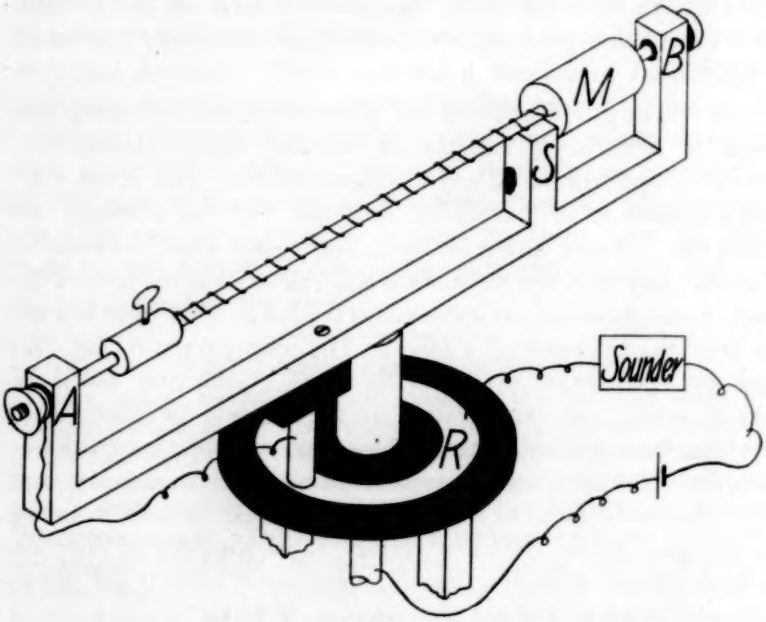


FIG. 2

whirling table and slip over the steel rod, A B, a closely wound spiral spring of say No. 24 steel piano wire. Clamp one end of the spring to the rod with a wire connector. To the other end attach a sliding mass of, say, 100 grams. When the table is rotated with an angular speed exceeding a certain amount the mass, M. will slide along the rod until it strikes the upright, B. The wooden stop, S, may be so placed as to prevent the mass, M, from slipping back more than, say, a single millimeter when the speed falls below the critical value necessary to keep the mass oscillating between the upright, B, and the stop, S.

It remains only to attach a bell circuit in such a way that one can easily detect the angular speed proper to keep the mass, M, teetering between the stops, S and B. This is readily done as follows. Insulate the rod, A B, Fig. 2, by means of hard rubber bushings. Place a collector ring, insulated, of course, on the bearing in which the vertical shaft rotates. A brush which rotates with the table and bears on this ring may be used to connect the rod, A B, in series with a dry cell and a telegraph sounder. The other end of the electric circuit is joined to the vertical shaft of the whirling table, so that when the mass, M, touches B the circuit will be closed and the click of the sounder heard. To each position of the clamp there will be found a critical angular angular speed such that the circuit is being continually made and broken.

But to each position of the clamp corresponds a definite elongation of the spring. Call the constant of the spring, K. Then to each critical speed w, corresponds an elongation e, such that

$$K\,e = m\,r\,w^2$$

where r is the distance from the axis of rotation to the center of gravity of the mass, m.

Here we have an illustration of the connection desired; for here a force due to an elastic deformation is balanced against a mass-acceleration. The action, if we may so call the centrifugal aspect of the force, is dynamical: the reaction, that is, the centripetal aspect, is statical. In this manner the spring may in thought at least be calibrated throughout any desired range.

A more instructive experiment is perhaps the determination of the acceleration of gravity by this means. For this purpose

it is only necessary to turn the table up on its edge and hold the rod, A B, *at rest* in a vertical position. Then set the clamp at such a point that the weight of the mass, m, is just sufficient to make it oscillate between the stops, S and B. This position of the clamp is described by the following equation:

$$K\ c = mg$$

Now replace the table in its horizontal position and rotate it at such a speed—indicated again by the sounder—that we have

$$K\ c = m\ r\ w^2$$

Eliminating $K\ c/m$ between these two equations we have for our laboratory equation,

$$g = r\ w^2$$

Certainly no one will imagine this an exact method for the determination of "g"; yet I have repeated the experiment sufficiently often to find that it is more accurate than the classical device of Atwood; at the same time it is more easily manipulated and is vastly more instructive to the student.

The upshot of the whole matter then is that, while mass-acceleration furnishes an excellent definition and measure of force, it is not a universally applicable criterion of force. Elastic deformations and other physical effects serve quite as well to indicate the presence of a force as does mass-acceleration.

May it not be well, therefore, *while holding rigidly to the Newtonian conception of force,* to make it very clear to the student that the one physical feature which is probably characteristic of all forces is a state of stress; and that these various stresses gravitational, magnetic, electric, elastic, etc., may be employed to equilitrate one another?

LATITUDE AND THE LENGTH OF DAY. A LABORATORY EXERCISE.

By Joseph F. Morse,
Medill High School, Chicago.

I. Almanac Study.

From an almanac answer the following questions for Chicago (New York or Boston) latitude:

(*a*) When are the days most nearly equal with the nights? (Equinox.)

(*b*) When are the days longest? How long?

(*c*) When are the days shortest? How short?

(*d*) When do the days change in length least rapidly? (Solstice.)

(*e*) What is the least, greatest and average change in length of day in two weeks' time?

To answer above questions compare times of sunrise and sunset at intervals of two weeks—from Jan. 1 to Dec. 31 (inclusive)—and tabulate results, as follows:

New York Latitude.

Date	Length of day. H. M.	Gain or loss.
Jan. 1	9—20	
		+ 16 minutes.
Jan. 15	9—36	
		+ 27 minutes.
Jan. 29	10—03	
		+ 30 minutes.
Feb. 12	10—33	
	etc.	

Of course, the conclusions reached by pupils from the almanac study will not agree exactly with the dates of equinox and solstice, the length of solstice days, etc., as computed astronomically from the *center* of the "fictitious sun" and without regard to *refraction*.

With younger pupils (physiography class) the teacher may explain how the bending of the sun's rays by the air, and the computing of sunrise and sunset from the upper edge of the sun lengthens the almanac day, and may call attention to the "sun fast" and "sun slow" column in the almanac, as suggesting a further reason—"that cannot be taken up now"—why the almanac data do not agree with those of the astronomer. The pupils should then be given the dates of equinox and solstice as computed astronomically—namely, March 21 and September 22, June 21 and December 22.

With astronomy pupils the almanac study may serve as an introduction to a study of the elliptical orbit of the earth, the law of the radius vector, and the difference between the "apparent" and "mean" solar days—all this in attempting to discover what is meant by "sun slow" and "sun fast" in the almanac.

II. Length-of-Day Curves.

The general facts regarding seasonal changes in length of day discovered by the almanac study may be pictured to the eye as follows:

Near the middle of a sheet of cross-section paper draw a *horizontal equinox line* twelve centimeters long, representing *one year's time* from March 21 to March 21. Divide the line into four equal parts. The middle is September 22. At the *solstice* points on this line—one-fourth and three-fourths of its length—draw *vertical* lines extending six centimeters above and below the equinox line, and let each vertical centimeter space represent two hours of time.

Since all places on the earth have equinox at the same times, all length-of-day curves will begin and end on the equinox line (March 21) and will cross it September 22.

When *days* are *longer* than twelve hours, let the curve run *above* the equinox line, and *below* it when the *nights* are *longer*.

The almanac gives Chicago's longest days as approximately fifteen hours around June 21, and longest nights as about fifteen hours around December 22. Chicago's curve would then move upward from March 21, cross the June solstice perpendicular one and one-half centimeters above the equinox line, and then descend, crossing equinox September 22, and reaching the December solstice perpendicular one and one-half centimeters below the equinox line. From there it would return to equinox level. (See appended diagram.)

The curve should be gently rounded at the solstice levels, to show the solstice periods of little change in length of day.

Does Chicago have more hours of sunshine or of night in the course of a year? Note that the space enclosed by the part of the curve above the equinox line just equals the space enclosed by the part below it.

All latitudes have their longest days and nights at solstice times, and everywhere on the earth the mid-winter nights are of the same length as the midsummer days.

North of the equator all places have their longest days around June 21, and the longest nights around December 22.

The almanac shows *New Orleans'* longest days and nights to be about fourteen hours. Draw the curve for New Orleans. How does it compare with Chicago's curve? How could the

curve of a place still nearer the equator differ from that of New Orleans? How would the "curve" of a place on the equator (Quito) run?

The longest days and nights at *Paris* are about sixteen hours; at Klondike about twenty hours, and on the arctic circle (Northern Iceland) twenty-four hours.

Draw curves for these places, and compare them with the curves of places nearer the equator.

At *Hammerfest* the sun does not set for about two months in midsummer, nor rise for two months in midwinter. To show this, the curve for Hammerfest must reach the twenty-four-hour day level, one month before June 21, continue on that level until one month after that date, then descend through September 22 to reach the twenty-four-hour night level one month before December 22, continue on that level to January 22, and then rise to March 21. Note that a curve cannot rise or descend beyond the twenty-four-hour levels, as there cannot be more than twenty-four hours of sunshine or night in one day. Continuous sunshine or night for a longer period than one day is indicated by continuing the curve on the twenty-four-hour level for the required length of time—two months in the case of Hammerfest.

Spitzbergen has sunshine for about four months in summer, and night for four months in winter. Draw the curve for Spitzbergen.

Draw the curve to show six months of sunshine in summer and a six-months' night in winter at the *north pole*.

As one goes *southward* from the equator the solstice days and nights increase in length with latitude to the same extent as north of the equator, but the longest nights occur around June 21, and the longest days around December 22. Draw curves for the following places, determining the length of their solstice days and nights by comparing their latitudes with those of the places north of the equator mentioned above:—Bloemfontein, Tasmania, Santa Cruz (South America), Antarctic Circle, and South Pole. Why are no places given corresponding to Klondike, Hammerfest and Spitzbergen?

The appended diagram shows the length-of-day curves for all the places that have been mentioned, as these curves would appear drawn on the same background.

Pupils should finally sum up their study of the relation of sea-

sonal changes in the length of day to latitude in a series of concise statements—somewhat as follows:

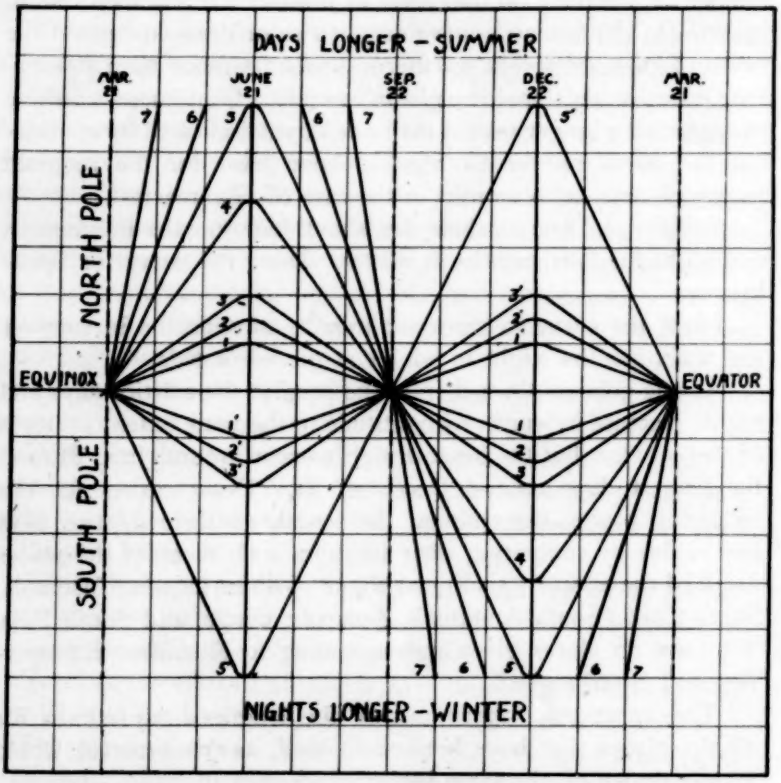
(*a*) The equator has a twelve-hour day the year through.

(*b*) All other latitudes have equinox only on March 21 and September 22.

(c) All latitudes have an equal amount of sunshine—six months—in the course of a year, the nights being as much longer than twelve hours in winter as the days are in summer.

(d) As one goes away from the equator the sunshine is "bunched" more and more into one part of the year, and the night into the other—the sunshine being thrown more and more around June 21 northward from the equator, and around December 22 southward from the equator.

LENGTH-OF-DAY CURVES



1 New Orleans
2 Chicago
3 Paris
4 Klondike
5 Arctic Circle
6 Hammerfest
1′ Bloemfontein
2′ Tasmania
3′ Santa Cruz
5′ Antarctic Circle
7 Spitzbergen

THE CHIEF AIMS IN ZOOLOGY WORK IN HIGH SCHOOLS.*

By Frank Smith.
University of Illinois.

The determination of what constitutes the best zoology work in the high school is a difficult problem, and for its most successful solution demands co-operation among those representing the different interests involved.

I shall make no attempt to discuss an ideal arrangement of high school courses and programs, but recognize existing conditions. In the majority of Illinois high schools, zoology is taught for one semester in the second year to pupils averaging 15 or 16 years of age.

Without personal experience with high school zoology either as pupil or teacher, I have felt keenly my lack of definite knowledge of the characteristics and possibilities of the human mind at the stage of development attained by the average second-year high school pupil. For my conception of their capacities I am dependent on the testimony of others who have had teaching relations with such minds. On the other hand, my association with the instruction work in the department of zoology in this institution for the past dozen years has afforded abundant opportunity for studying the output of Illinois high schools of all grades, from best to poorest, and also of studying a very considerable number of the zoology teachers found in those schools. In fact, I am in part responsible for defects in the preparation and ideals that are displayed by the considerable number of such high school teachers that have had their preparation at this institution during the past dozen years.

At the outset, before stating what I think the main object of the secondary course in zoology should be, I wish to state clearly that I think it should not be planned with reference to subsequent work in zoology at college or university. Since but a very small percentage of the high school pupils in zoology are to continue a study of the subject beyond the high school, it seems clearly wrong to have any pressure brought to bear to bring about any modification of the high school zoology course for the purpose of better adapting it to serve as an introduction to college courses,

*From a paper read at the High School Conference held at the University of Illinois, Feb. 16, 17 and 18, 1905.

if such modification in any considerable degree diminishes its usefulness for those students who are to take no further work in the subject. I am convinced that there is so much difference between the course that serves best as a complete course and the one that is best as an introduction to college courses that it is unwise to make the one serve the purpose of the other or to attempt a compromise between them, I shall, accordingly, favor the attempt to arrange a course best adapted to meet the needs of a majority and let the college and university get along as best they can with the relatively small minority. This eliminates any possible conflicting interests and leaves us with the same object, viz.: to elaborate the best course in zoology for the second year high school pupil who is to have no subsequent work in that subject.

So much has been written and said within recent years concerning zoology courses in secondary schools, their objects and methods, and the ground has been so thoroughly gone over that we have abundant material from which to choose those ideas that promise to be most useful and improve on them if opportunity offers.

Perhaps the most important advantage within reach of the student of zoology in the secondary schools is a cultural one as shown by the attitude of mind which it may give him toward the facts and problems which he must face in after life. If his work has been properly directed it should help him to gain the power of independent thinking, should increase his ability to accurately judge the value of evidence and so make him better able to reach safe conclusions. Such results are highly desirable if attainable and amply repay one for the time and energy involved. That they are obtainable is firmly believed by some of our prominent educators.

I think that it is quite commonly agreed now-a-days that the number and kind of facts gained are of less consequence to the student than are the mental processes involved in their acquisition, and practically all agree that the method should be that commonly known as the scientific method, which, in its complete form, involves a series of observations, their classification and generalization, the invention of hypotheses or explanations followed by deductions and experiments for the purpose of testing the correctness of the hypotheses or explanations.

It is, of course, not to be expected that the student will go through all of these steps from observations to verified generalizations any considerable number of times, but that he may do it a few times in cases which are comparatively simple and that, in general, he will be expected to bring the facts gained from his own observation into relation to each other and also to facts obtained from other sources. Furthermore, it is not to be expected that the student is to get all of his facts by any such method, but that a goodly part of his time, at least four forty-minute periods per week, is to be spent in the laboratory or field, getting facts first hand from his own observations and experiments, and that with these as a foundation he is to gain other facts from his teacher and from books, and under such guidance as necessary he is to organize these facts into a useful body of knowledge which may be available in after life. This body of knowledge should, at the least, contain some of the more important generalizations of biology, as well as some of the more useful facts of physiology and economic zoology.

At the end of his course in high school zoology the pupil should realize that his human physiology is simply one province of a more general animal physiology and that there is a much closer relation between plants and animals than he had previously supposed. After his high school course in botany he should no longer think of plants, animals and man as widely distinct, unrelated objects, but rather as different forms of living matter adapted to different modes of life.

In educational work as in other fields of human effort it is often much easier to state in a general way what objects and aims are desirable than it is to give directions for their accomplishment, but our discussions cannot be helpful to those teachers most needing help unless they lead to the formulation of quite definite detailed outlines of the course of procedure necessary for them to follow in order that they may improve as teachers of zoology.

Some well-known educators and writers consider that facts of structure are the most available and most useful material for the pupil, and that his time and energy should be chiefly employed in accumulating such facts and classifying them, so that he may be able to frame definitions of the different groups of animals. To such persons the chief value of zoology and botany to the

pupil lies in the fact that they are classificatory sciences. There can be little doubt that work of that sort consistently carried out is better than the aimless hit and miss kind of work which is so common in our schools and which leads to but little in the way of mental training or useful knowledge, but I am heartily in sympathy with the idea held by some that function and structure rather than structure alone furnish much more useful material for the development of the pupil's reasoning powers as well as more useful material for his stock of general information.

There are two recent contributions to the literature of secondary school zoology with which teachers should be familiar. One of these is the new book by Lloyd and Bigelow entitled, "The Teaching of Biology" and published by Longmans, Green and Co. Chapter VIII of the part devoted to zoology gives suggested outlines of work on which can be based excellent courses of study for either a half year or a whole year.

The other contribution to which reference is made is found in "Science" for December 16, 1904, and is a report of a committee of the Eastern Branch of the American Society of Zoologists, appointed to outline a course in zoology for secondary schools, which should best meet the needs of such schools and should also be worthy of acceptance for entrance credit by colleges and universities. The report outlines work for half year and whole year courses, and was adopted by the society at its annual meeting in the latter part of December.

I will now attempt to give the general features of a good course in zoology as judged from my point of view.

If there has been no nature study work in the grades, the first few weeks might perhaps be spent most profitably in laboratory and field work on the external characters, habits and life histories of several types of insects and of a few other common groups of animals, not forgetting the birds, but a considerable part of the course should consist of work from other than the natural history point of view. Let a few desirable forms be chosen, such as the crayfish and frog, also Hydra, Amoeba and Paramoecium if equipment permits, and let them be studied with reference to internal and external anatomy, and especially to their physiology and environment. Either coincident with the work on the first type form studied in this way or just preceding it there should be a few exercises and simpler experiments which

should make as clear as possible the simple chemical phenomena of animal life. A sufficient knowledge of carbon, hydrogen, oxygen and nitrogen and their relation to water, carbon dioxide and in a general way to proteids, fats and carbohydrates is just as much within the reach of a fifteen or sixteen year old pupil in zoology as of the same pupil in chemistry. That water, carbon dioxide and comparatively simple nitrogenous materials arise from oxidation of the organic substances of the body can certainly be made intelligible. The significance of the terms acid, alkaline and salt and the use of an indicator like litmus paper should present no difficulty.

If the pupil has not already had an opportunity to see the results of simple experiments dealing with dialysis and with the digestion of proteids and starch, it would be advantageous to give them in connection with the preliminary work in chemistry.

With these necessary facts of physics and chemistry as a foundation the pupil can be made to realize something of the conditions essential to the maintenance of living matter while in a state of activity. The necessity for food, together with the real purpose of digestion, can be made clear. A more adequate notion of respiration can be given than the one implied in the too frequent answer, "to purify the blood" with its implication that animals with no blood have no respiration. Still further, the significance of excretion becomes apparent. The pupil is now prepared to understand why the very small animals living in water or in very moist situations may be much more simple in structure than those living in comparatively dry air or than large animals in any situation. He is also prepared to understand something of the relation between the real assimilation, respiration and excretion of the living matter throughout the tissues of the complex body in which the circulating fluids act as a surrounding medium, and the corresponding activities of smaller animals living in water, also the somewhat different nature of the activities of special organs of respiration, excretion and the like in the complex animals. One compound microscope, to be used in helping the pupils of a class to gain a conception of the multicellular nature of Metazoa and for exhibiting the activities of Amoeba and a few Protozoa, seems to me to be an indispensable adjunct for a successful course in zoology. Additional microscopes, although highly desirable, are not so essential.

Laboratory work on the structure of animals must still constitute an essential and relatively large part of high school work in zoology, but it becomes much more interesting and profitable when the organs are studied as structures for the performance of necessary functions under the conditions fixed by the environment.

For the greater part, the directions for the pupil's work should be so planned that they continually assign problems for him to work out rather than make extensive use of the verification method of work, and especial effort should be made to plan some experiments which involve all the steps of the scientific method.

More general features of development, such as the origin of animals from single-celled ova and the subsequent cell division and differentiation should receive attention, but the details of mitosis and maturation would probably better be omitted.

As to the matter of evolution the tact of the teacher and local conditions will determine whether it should receive much attention. It would doubtless be better for the teacher not to assume the part of a special advocate for the theory, but it seems that so important a body of ideas should not remain entirely unnoticed. A general statement of the theory and that it is believed by many scientists to be true, although not absolutely demonstrated, ought not to do harm, and certainly a general notion of evolution seems to be an essential part of the equipment of any well educated person.

I think that in many of the better high schools of the state excellent work is now being done in zoology. There is sometimes a tendency to give too much attention to anatomical details of which no especial use is made subsequently and to give too little attention to physiological and environmental aspects of the animal, and especially is there a deficiency in those phases of the work which exercise the pupil's ingenuity in testing the accuracy of his generalizations, which are often made on very scanty data. Too large a part of the work is mechanical and observational, while too small a part is calculated to aid the development of the reasoning powers.

A very obvious deficiency in the students from the average high schools and from those below the average is their lack of knowledge of even the elementary notions of physiology. We usually find the explanation readily enough when we get the teachers from such schools into our classes.

I know full well that the life of the science teachers in our average high schools is a strenuous one, and that the number of classes that they are obliged to teach and the variety of subjects with which they must be familiar is so great that it must often seem to them that the easiest mode possible for laboratory management is the only mode possible. I also realize that the management of the laboratory work of large zoology classes is more easily accomplished when the work is chiefly anatomical. It may often times happen that from sheer necessity the teacher seems driven to a course of procedure that his own best judgment condemns, but, on the other hand, there are teachers who are able and willing to modify the character of their instruction work when convinced that a modification is desirable.

What relation has the high school zoology to the subsequent zoology work of college and university? I fancy that many teachers of college classes would prefer that the students coming to them should have had chiefly natural history work and have a general interest in animals, but not have much knowledge of type forms. I should certainly advocate such a course for the high schools if ninety-five per cent instead of five per cent of the pupils taking zoology were to follow it with more zoology at college. The pupil who has had Hydra and Amoeba and other such forms in one of our large high schools naturally feels that his time is being wasted if he is asked to study them again at the university, and too frequently is really at a disadvantage because of an unwise attitude of mind toward his work. This might in many cases be obviated if the teachers in such schools would take care to set their pupils right in the matter and not leave them with the impression that they have learned all that there is to be known about the forms they have studied.

We often hear the college graduate berated for requiring his high school pupils to study the "college frog" instead of the "high school frog." I have no doubt that there is often ground for complaint in this matter, but I do not value very highly the high school frogs that have no internal organs nor functions.

I can see no sufficient reason why there should be any differences between the course in general zoology for the college man and the one for the high school man other than those made necessary by the differences in mental characteristics and the time and equipment available.

ANALYSIS OF NITRIC ACID.

By B. W. Peet.
Michigan State Normal College.

Chemistry has to deal with the composition of things. Hence, any experiment that illustrates in a simple way the composition of the common chemical compounds is a valuable one for beginning students in chemistry.

Most texts take up the study of acids, bases and salts, and the composition of ammonia before the study of nitric acid, so the student is able to grasp the full meaning of the experiment as here given.

(a) Any solution that contains hydrogen ions will turn blue litmus red. Add a drop of nitric acid to a strip of blue litmus paper. It turns red, hence nitric acid contains hydrogen.

(b) Into a test tube put 4 or 5 c.c. of water, add 10 or 12 drops of concentrated nitric acid and stand in the test tube rack, or an empty wide-mouthed bottle. Add a piece of sodium hydroxide about twice as large as a good sized pea and shake a few times, then add a few pieces of aluminum wire and, if necessary, heat over the Bunsen flame until the action is quite vigorous. Test the odor of the escaping gas and note its action on moist red litmus paper. It is very evident that ammonia is liberated. When sodium hydroxide is placed on aluminum, hydrogen is liberated and the nascent hydrogen reduces the nitric acid, forming ammonia and water. The student already knows the composition of ammonia and can readily reason that the source of the nitrogen must be from the nitric acid.

(c) Place about a gram of coarsely powdered iron sulphide in a test tube, cover with concentrated nitric acid, and heat a few minutes in a hood. Allow the solution to cool, dilute with two or three times its volume of distilled water, decant a portion of the dilute solution and test for the SO_4 ion by adding barium chloride. A heavy white precipitate of barium sulphate indicates the presence of the SO_4 ion. The student can readily reason out the source of the oxygen. The experiment thus shows nitric acid to be composed of hydrogen, nitrogen and oxygen.

A GAS PIPETTE.

By P. G. Agnew.
Pontiac, Mich.

Having noticed in the March number of School Science and Mathematics the description by Mr. J. A. Griffin of an apparatus for transmitting gas from one vessel to another, it has occurred to me that the form of gas pipette here figured may be of interest. The bulbs and tips are immersed in the water, or other fluid, and the bulb *A* filled by suction, (*B* does not fill at first.) The water is then forced from *A* into *B*, the tip brought under the vessel containing the gas to be transferred, and *B* filled with gas. A scratch at *c* allows the same quantity to be taken each time. It would be more convenient to have *B* made to hold 5 or 10 cm³. If desired, a drop of water may be drawn into the tip to prevent the gas from being contaminated by air.

I have found that elementary students learn to use the instrument without trouble.

Perhaps the form is already in use but I have not seen it described.

A SIMPLE ACID AND ALKALI-PROOF LABEL FOR REAGENT BOTTLES.

By E. P. Schoch.
University of Texas, Austin.

The accompanying cut shows reagent bottles which, together with some three hundred others, were labeled three years ago and have been in constant use ever since. All of them have withstood exposure to concentrated acids and alkalis and mechanical wear and tear satisfactorily.

The labels were printed with rubber stamps direct on the

glass, using thick printer's ink. Since the printer's ink would not dry appreciably, the print was immediately brushed over lightly with ordinary melted paraffine, which by using a flat brush can be done with one light stroke without disturbing the ink. The rough edges of paraffine were washed off with gasoline. Printers' ink was used because it is not affected by chemicals. The paraffine serves to protect the print and also as a background. There is no paper to corrode, no mucilage to fail.

Supplement No. 10 to Nos. 85-90 of the *Communications from the Physical Laboratory of the University of Leiden* has just been received by American subscribers. This particular "Supplement" describes "The Influence of Admixtures on the Critical Phenomena of Simple Substances," and traverses in a general way the work of Andrews, van der Waals, Teichner, Kuenen, de Heen, and others, on this subject. The laboratories of Leiden, of which Prof. Dr. Kamerlingh Onnes is the head, are admirably equipped, especially on the cryogenic side, and are putting out some of the best work of the world in this line. It is worthy of remark that the "Communications" are mainly in English, as a language on the whole more available for the scientific world than German or French.

SOME DIFFICULTIES OF THE MATHEMATICS TEACHER.

MISS CORA STRONG,
State Normal School, Duluth, Minn.

It is perhaps a hazardous thing to begin a paper on mathematics with a Scripture reference. But I give my word of honor that a text does not, in this case, mean a sermon, perhaps the reader will let me remind him of that doughty old Hebrew warrior, Caleb. It will be remembered that during the conquest of Canaan he came to Joshua asking for a certain mountain as his inheritance. "I am an old man," he said, "but I am as strong as ever. As my strength was then (in my prime), even so is my strength now, for war, both to go out and to come in. Now, therefore, give me this mountain, for (and here lies the point of my reference) *for* thou heardest in that day how the Anakims were there and that the cities were great and fenced." (Josh., 14:11-12). The giants and the fenced cities that we, as teachers, must oppose—these form my theme. But we are to survey our enemies with the spirit of this old fighter in our hearts, prompting each of us to say: "Give me this work, not in spite of its obstacles, but just because its obstacles are so peculiarly great. Let me have the stern joy of overcoming foemen worthy of my steel."

To some of us the giants in the realm of mathematics seem peculiarly tall and terrible, the fenced cities more numerous than elsewhere and less open to assault; or, to drop a figure, that may seem to partake of the mock heroic, the difficulties of the mathematics teacher seem especially large in number and serious in nature. To state two or three of these difficulties, to suggest a few means of overcoming them, is all that this paper can hope to do.

One of the fundamental problems which we must face has to do largely with arithmetic. Algebra and geometry have, it is true, a utilitarian, every-day value to the worker in physical science, pure or applied. But to the ordinary child their worth lies mainly in the thought training they afford. Hence the teacher of algebra and geometry has a single definite object set before him. With arithmetic, the case is different and more complex; both utility and culture must be included in the object. The child must know arithmetic to earn his bread and butter; yet the study

of arithmetic is largely wasted if he does not find in such study a training in abstraction and generalization, in clear thinking, in close reasoning, in exact expression, in patient attention to detail. How are two objects, utility and culture, to be best combined and balanced in thought and in actual accomplishment?

An absolute answer cannot, of course, be given to this question. But a few simple and helpful considerations may be named. *First,* as to utility:

a. The average child will need a comparatively small amount of arithmetic for his daily needs.[1] Numbers larger than billions, for example, and decimals smaller than thousandths, will not enter into his computations; his compound numbers will be covered by a few tables and will rarely include more than two units. And so on through the whole range of topics. It is the teacher's business to know how few fundamentals there are in arithmetic viewed from the utilitarian standpoint and to see to it that the pupil masters, at any cost, these few fundamentals.

b. Most teachers agree that those topics in arithmetic which give positively false ideas of modern business life should be omitted—*e. g.,* Alligation, True Discount, problems in Stocks and Bonds involving unused quotations or a fractional number of shares. Some would carry the process of excision still further, cutting out most of commercial arithmetic, on the ground that the child is too immature to grasp its truths in the grades, while he will learn what he needs to know of these, and learn it quickly when he is confronted later with the actual conditions of the business world. This is the view taken by the Committee of Fifteen. It has much to commend it, especially when one remembers how few grade teachers have that first-hand knowledge of business needed by the instructor in commercial arithmetic.

c. However much we may differ on the second point, we are a unit on the third, viz., that the child who completes the eighth grade should be quick and accurate in computation and expert in the solution of simple every-day problems. And we are equally a unit in saying that such accuracy and speed in the fundamental operations are rare. Possibly the main trouble is that we modern teachers give too much time to the more difficult applications of arithmetic and are afraid of drill in pure number and in simple solutions. There is nothing degrading in drill and nothing dis-

1 See Teaching of Elementary Mathematics (D. E. Smith), p. 21.

tasteful to the child when the drill is properly conducted. It leads directly to the desired result and we should have more of it.

To sum up: In making arithmetic a useful instrument in the child's hands, we must omit those topics which give him false business ideas, see that he masters the topics that he will surely need, see that he is quick and accurate in every-day problem solving and computation; whether we should emphasize business arithmetic or not is an open question.

Second, as to culture:

a. Some teachers hold that the subjects of arithmetic, as affording material for culture, are more or less on a par; others hold that the less the direct use of a topic the greater its culture value. In either case, modern arithmetic is so rich in content that even the most ardent culture advocate can readily dispense with the obsolete business forms and customs condemned by the business man.

b. To say that the phase of the study we present must fit the growing minds of our children seems a truism. Yet often we so forget, or misapply, this truism as to deaden our pupils' powers of thought. From children in the lower grades, for example, we have no right to expect logical reasoning. To train eye and hand, to strengthen the memory, to secure a correct insight into the nature of number, to develop through counting the power of abstraction, to cultivate the mathematical imagination—these must be the chief aims of the primary teacher. Gradually the children may be led to pass by inference from what is given to what is required, and to separate into steps the reasoning employed. Later still they may be led to make such inference and analysis unaided by questions. Then, and not till then, are they ready to give a formal explanation of a problem. Even in the higher grades care has to be taken that too severe exercises in logic are not demanded—*e. g.,* such a long chain of reasoning as that involved in the Eucledian method of finding the greatest common divisor.

c. While logical thinking on the student's part is of supreme importance, *independence* and *exactness* of thought are close seconds. The ability to discover truth for himself (from observation, experiment, study of the text or inference), the alert and critical attitude in class, the habit of formulating his own rules rather than taking them ready made—for these attainments on

the part of the pupil the teacher must constantly strive. Against that pathetic haziness of vision, that rooted habit of inaccuracy so often found among first year students in the normal school, the warfare must be equally earnest. Few definitions should be learned, but these few should be so carefully framed as to find no contradiction in the broader conceptions of the higher mathematics, and they should be expressed with the utmost accuracy possible. At every point satisfaction with anything short of the *exact* truth should be discouraged.

To sum up: In order to get the full culture value of arithmetic the child needs to study no topic condemned by the business man; the transition from arithmetic as an art to arithmetic as a science and an exercise in logic is to be gently made; independence and exactness of thought are to be emphasized next to logical reasoning.

The problem of reconciling utility and culture is, as we have seen, the special problem of the arithmetic teacher. But there is another fundamental difficulty which extends through elementary and secondary work and even into the college—the difficulty of proper division of emphasis between content and form, thought and expression. Only a few weeks ago I was comforted when a university dean to whom I had poured out my perplexity on this point answered me as follows: "The difficulty you mention is one that always troubled me in my teaching, and I never felt that I fully succeeded in securing the appreciation of formal statement."

The professor to whom I have referred went on to say: "I think I did succeed in securing an interest in the subject and I did succeed in developing good geometric minds—to my way of thinking, much more important. The student must get the inspiration of the subject first and then every effort should be put forth to secure a fair degree of elegance in expression." While admitting that the attitude taken by the professor may be entirely proper in the college class, my experience leads me to feel that form should receive a larger degree of emphasis in the secondary school. The importance from the business standpoint of accuracy in computation has been mentioned. But business enterprises need not only good computers, but boys and girls with the habit of using good English, with a feeling for clear expression and for orderly arrangement. From the standpoint of culture, form should be em-

phasized, because it reacts on the pupil's thought. Inaccurate and slovenly habits of expression foster inaccurate and slovenly habits of thought. On the other hand, every teacher is familiar with the clarifying influence on his own thought of the honest attempt to express himself clearly in class. After even a few months' experience with average students, the mathematics teacher has a rich collection of errors in form—mechanical mistakes in computation, misspelled words, pronouns whose antecedents are lost in the misty past, equations untruthful in form, *e. g.*, ($5\times3+2-5=12$, given as $5\times3=15+2=17-5=12$), reduction which implies the change from degrees to hours merely in division by fifteen, algebraic problems half stated, geometrical theorems inaccurately phrased and proved in haphazard fashion. Even if the examples assigned have to be made simpler, it is well worth while to insist upon entire mechanical accuracy; even if less ground can be covered, it is worth while to fight for correct spelling, good grammar, accurate memorizing, orderly arrangement, adequate and truthful symbolic statements.

Those of us who love mathematics as mathematics and feel that "beauty is its own excuse for being" fail sometimes to give due consideration to a third fundamental problem—the problem of so presenting the subject to our pupils as to give them a maximum of interest and joy in their work. Some students like the abstract character of the exact science, but to others this comparative remoteness from human interests is a positive drawback. The rigor of mathematical reasoning, also, tends to discourage many a student who has not formed the habit of working intensely or of thinking to a point. How shall we make the subject warm with human interest? How tempt our pupils to go deep enough into the work to feel its charm?

One of the best means at our disposal is, of course, the correlation of the work in mathematics with the work in other branches, notably nature study and manual training. Many primary teachers now make first grade number work purely incidental and instrumental; undoubtedly the interest of pupils in the higher grades may be greatly quickened by a partial extension of the same method to their work in arithmetic and geometry. The high school teacher, perplexed over the correlation of mathematics and physics, is watching with interest the success of some recent attempts to construct simple physical apparatus and perform

simple physical experiments in connection with grade arithmetic.

Another means of awakening interest in mathematical work is sometimes available—viz., the correlation of the study with some work the pupils is doing or hopes to do. Possibly all of us know the story of the youth, who hitherto dull in mathematics, suddenly developed an almost alarming interest in the geometry of the circle, and read this portion of his text with astonishing rapidity, because he had decided to make a balloon and found that a knowledge of circular sectors, etc., was needful in its construction. I have myself known of high school boys whose interest in mathematics was due to their intention of becoming engineers.

Another and comparatively little used means of adding human interest to the study is to make free use of the history of mathematics. The study of the decimal system becomes charming when we trace the origin of the system to the habit of counting on the fingers, and find in the number words of savage tribes the evidence of such counting. In one South American tribe, e. g., the word for five means "a whole hand," the word for ten, "two hands," the word for eleven, "one to the foot," the word for sixteen, "one to the other foot," etc.* My classes have always been interested in the struggle of early mathematicians with fractions. The Egyptians, for instance, went through with what seems to us a fearful amount of labor in reducing each fraction to the sum of several fractions, each with the constant numerator one. The Babylonians, equally unable to grasp the simultaneous variation of numerator and denominator, usually kept the latter constant and sixty or some power of sixty.† Geometry, from Pythagoras with his mystic brotherhood to Pascal with his use of original investigation to allay the pain of toothache, fairly bristles with historic incidents and famous problems. The applied mathematics of physics, astronomy and engineering affords the same kind of material for advanced students. "I am sure," says one mathematician, "that no subject loses more than mathematics by any attempt to dissociate it from its history."

To correlate the study with allied subjects or interests, to present its topics in their historical setting—these are helpful means of securing interest in the pupil. There is another means, often more potent, but difficult to analyze and difficult to acquire

*1. Fine's Number System of Algebra, p. 83.
†2. Ball's History of Mathematics, pp. 3-4.

—the drawing and constraining force of the teacher's personality. We can look back to our own mathematics teachers and see some elements of such a personality—love for the subject and a sense of the latter's dignity, an enthusiastic conviction of the nobility of the teacher's work, transparent honesty, intellectual and moral, earnestness of character, courtesy and patience springing from genuine respect and love for the students. But in the actual building up of such a character no one can help us. This part of our problem we must solve alone, or, at our peril, leave unsolved.

NOTE ON AN "INDEPENDENT CRITICISM."

By T. M. Blakslee.
Ames, Iowa.

Some good points are made in Professor Greenwood's paper in the March number of this magazine. Another is exemplified in Wentworth, 1, p. 1 and the first of his "Solid Geometry." In 492 he repeats the usual definition of a plane involved in 1, p. 1. In 493 he defines "determined." In 494 he says: "For a plane may be made to turn about any straight line AB in it." He gives a picture of several planes cutting in a straight line AB. On this assumption of his Theorem 1, "If two planes cut each other, their intersection is a straight line," he proves the determined principle. If we call these Y and X, he proves X by Y, then Y by X. This is the method of nearly all "the texts in common use." All the "folding proofs of plane geometry are subject to the same assumption. All this could be avoided if after the usual definitions of a plane and parallels the following theorem and proof, needing no figure, be given.

Theorem. If two planes have three points which are not in the same straight line in common, they have all their points in common.

Let M and N be two planes having three such points, A, B and C in common, and let P be a point in either.

To prove P in both planes.

Proof. Draw through P, any straight line that will cut both AB and CB. Let it cut AB in H and CB in K. Then

A and B being in both planes, H is in both planes.
C " B " " " " K " " "
H " K " " " " P " " " Q. E. D.

DISCUSSION OF PROFESSOR COULTER'S PAPER IN FEBRUARY NUMBER.

Editor of the Department of Biology, School Science and Mathematics:

Until now I have been unable to respond to your invitation to present some discussion of Professor Coulter's interesting article in the February number of SCHOOL SCIENCE AND MATHEMATICS, on "The Influence of the Teacher's Research Work upon His Teaching of Biology in Secondary Schools." This as well as other articles along similar lines by Professor Coulter, have done much to stimulate thought among secondary school teachers.

A few years ago I believed and advocated that every high school science teacher should do some original work, even if it could not be a finished investigation, or thesis, in the sense of what the Germans call an "Arbeit." It will appear subsequently that my reasons were quite different from Dr. Coulter's. At that time it seemed to me that all teachers could make and record simple observations, collecting data that would be useful to investigators. Those in whom investigators have discovered ability to do more, might be encouraged to go on and add their mite to advancement. To my notion Professor Coulter's second class of teachers, "who cannot do research work," would surely be able to make very useful observations though they themselves might not go farther than this. They must have the faculty of observation and accuracy, otherwise they could not even teach. These are such a large class of science teachers in secondary schools that, if we accept Professor Coulter's classification and his rather radical proposition to shut up departments that cannot be supplied with investigator teachers, then there would be few high schools in which any science would be taught.

There are teachers in secondary schools who, I believe, could do some research work but for the too conscientious application to their school duties. They ought to be included in the class of teachers "who can do research work." To justify their existence and ameliorate their condition I would compare them with university professors whose eminent ability not only to conduct research but also to do it themselves, is well known, but who are not producing all they might because of an inflexible determina-

tion to attend personally to all business routine that is connected with their department, thus spending time that should be given to enriching science by their more frequent contributions.

In the matter of insuring accuracy and independence there is no doubt that research will benefit both university and high school teaching, but its value for "keeping the teacher current" applies rather to the former. And here, I believe, we come to the parting of the ways. It will be more generally recognized in the future, I think, that university and secondary school teaching differ both as to content and especially as to method. It has impressed itself on me only after considerable experience, and much effort to find an explanation of the frequent complaints made by college teachers against biology teaching in secondary schools.

First, as to method: It will readily be granted that accuracy is increased by investigation, but unless there is a habit of accuracy no valuable research work will ever be done, besides it is a faculty that teaching, as well as other disciplines, can give. I would like to interpret Professor Coulter's too modest confession of early blundering as the experience of many another teacher-investigator and, therefore, not so much to be regretted. To lead the pupil up, step by step, beginning with simple concrete things, requires an understanding of the topic that comes far more by repeated attempts to teach clearly, simple minds, than by any amateurish investigation that high school teachers can do.

Second, as to content: The primary function of the high school is recognized to be *training* and *development,* while the university, especially in undergraduate work, lays most stress on informing. Of course the teacher who conducts investigation in a university is doing the highest kind of teaching—including the best of all other kinds. This is almost always graduate work.

From much that has been written on the teaching in secondary schools (especially in science), and my own mistaken earlier belief and subsequent experience, I am becoming more and more convinced that the immature mental development in high school pupils and how to meet this condition in these schools is not well understood.

While I believe in the main Professor Coulter's contention that the teacher should keep in touch with investigations in his subject, for, to teach a little he must know much more than can

be taught the pupil, he must be as broad as possible and realize the relativity of all knowledge. Yet I would consider him unwise if he attempted to teach the results of any investigation until it is confirmed by a second investigation or has stood approved by scientists. Above all things I believe it would be poor pedagogy to teach any controversial question in high schools; in universities, on the other hand, the latest *views* must be discussed.

Professor Coulter says the investigator who is a teacher will not "attempt to present things beyond the grasp of his elementary pupils." In the same connection it is tacitly admitted that this is not because the teacher is also an investigator—for he says the pure investigator will do this—but that it is because he is a good teacher, for he further says "one of the fundamentals of teaching is to relate material to the capacity of the pupil." The implication immediately after that, that the teacher needs to be an investigator to lead the pupil beyond his depth, does not seem to be valid since this would be rather "bursting capacity" than an efficiency test. It may be that Professor Coulter did not mean this, otherwise the teacher would belong to the first of his three classes.

While it is true that investigation in any subject will give the teacher first hand knowledge and will make his subject not "difficult to teach," its benefits will be limited to the subject that the teacher can investigate, and for making other subjects his own in order to present them in an original fashion he is after all dependent on the teacher's instinct. The fact that a born teacher can do this shows that the power is not peculiar to the investigator. On the other hand, I heartily approve what Professor Coulter says about the broader teaching that follows keeping up a little investigation in any line.

Finally, I wish to endorse Professor Coulter's propositions, that "investigation increases accuracy, insures independence and insures that the teacher will keep close in touch with the advance of his subject"—all qualities that an investigator must have, but which the teacher should cultivate not so much for the reaction it may have on his teaching as for enabling him to do some kind of simple investigation to contribute to the fund of knowledge.

L. Murbach.

Detroit, April 8, 1905.

THE USE OF GLASS BLOCKS IN REFRACTION.

By Henry Garrett,
England.

Early in a school course on Light it is usual to introduce an experiment with pins and glass blocks, in order to determine the "index of refraction." The customary method is open to the objection that it assumes, on the part of the teacher, a knowledge of the result to be arrived at, and is, in consequence, purely a verification of a known law. But the experiment may be more broadly treated and utilized to lead, on inductive principles, not only to the existence of an "index of refraction," but also to the examination of the limiting case.

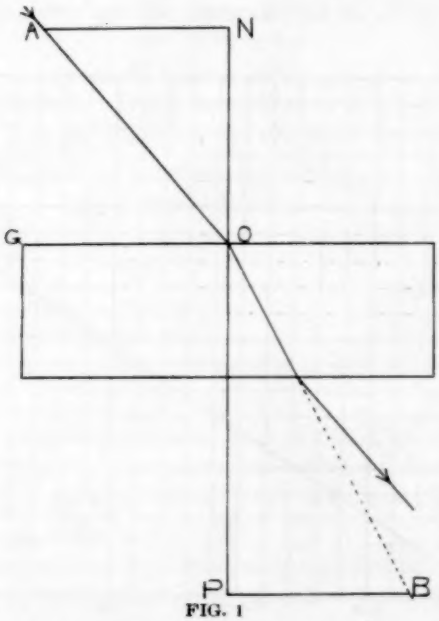


FIG. 1

In the first place, pupils will be set to find the paths of several rays, of varying obliquity, passing through the glass. It is at once apparent that the amount of bend increases as the incident rays become more inclined to the normal. A ray striking normally will also be found to be undeviated. It now becomes necessary to examine carefully what connection exists between the directions of the incident and refracted rays. To do this the inclination of each ray must in some way be measured. The usual

method of expressing an incline, such as may be found on every railway, is to describe it as a rise of 1 in 100, 2 in 225, etc. In case the ray falls normally on the glass surface, the incline is zero. For any other direction the incline is measured by drawing a perpendicular from any point, on the direction of the incident ray, to the normal, *e.g.*, if NO (Fig. 1.) be the normal to the glass surface, AO the direction of an incident ray, AN the perpendicular drawn from any point A in AO to NO, then the incline will in this case be $\frac{AN}{AO}$. In the same way the incline of the refracted ray OB will be $\frac{BP}{BO}$, where BP is the perpendicular from any point B, in the direction of the refracted ray, to the

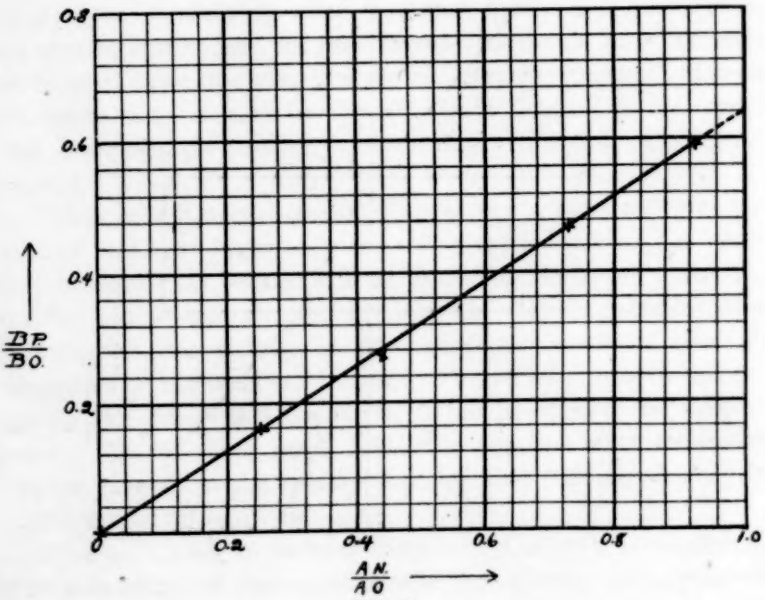


FIG. 2

normal. When these relations have been determined for each pair of incident and refracted rays, the next course will be to obtain a graphical picture of the connection between them. In an actual experiment carried out by a boy with crown glass, the following ratios were obtained:

Taking now the incline of the incident ray, $\frac{AN}{AO}$, as abscissa, and that of the refracted ray, $\frac{BP}{BO}$, as ordinate, the accompanying curve (Fig. 2) is obtained. As will be seen, it closely approximates to a straight line, one point only being appreciably out.

$\frac{AN}{AO}$	$\frac{BP}{BO}$
0·00	0·00
0·25	0·16
0·45	0·26
0·72	0·46
0·92	0·58

The meaning of the curve will be clear to any pupil who has worked through a satisfactory preliminary course in physics, and he should be able to write it down as

$$\frac{AN}{AO} = k. \frac{BP}{BO}$$

where k is a constant. If the term *sine* is not yet known to the pupil, he may now be given the name, since he will understand what it indicates, and the equation becomes:

$$\text{Sin } i = \text{k Sin r},$$

or

$$\frac{\text{Sin } i}{\text{Sin r}} = \text{k},$$

where i and r are the angles of incidence and refraction respectively.

The above evidently amounts to a rediscovery of Snell's law in the case of glass. The numerical value of k—the index of refraction—may either be taken from the curve, or calculated from each pair of ratios in the table.

Pushing the consideration of the curve further, it will occur to the teacher to ask what is the greatest value that Sin i or $\frac{AN}{AO}$ can have. It will evidently be when the perpendicular AN and the hypoteneuse AO become identical, or $\frac{AN}{AO} = 1$, that is, when the incident ray is parallel to the glass surface GO. Assuming that the above law holds for all possible values of sin i, the maximum value of sin r or $\frac{BP}{BO}$ can be read off from

the curve. In the case before us it is 0.64. The angle corresponding to this, as taken from a table of sines, is 39° 48′.

If now the ray be considered as reversed in direction, proceeding outwards from the interior of the glass, the physical interpretation of the result will be that a ray striking the inner surface of the glass at an angle of 39° 48′ with the normal will travel along the surface of the glass, whereas any ray making a smaller angle than this will emerge. In other words, 39° 48′ is the "critical angle" for glass. Looked at somewhat differently, the result given by the equation

$$\text{Sin } i = k \text{ Sin } r,$$

in the special case where $\sin i = 1$, is

$$\text{Sin R} = \frac{1}{k},$$

where R is the "critical angle."—*School World.*

THE VALUE OF VACCINATION.

By Wilfred H. Manwaring.
Department of Pathology and Bacteriology, University of Chicago.

"Do you advocate or oppose vaccination? And, why?"

Few teachers who are asked these questions can cite authentic facts in support of their belief. A brief summary of facts brought out by governmental inquiry into the results of vaccination, might therefore be of value.

Historical: Vaccination was introduced in England in 1798, Its introduction was preceded by twenty-four years of observation and experiment that lead Jenner to believe that the inoculation of a human being with cow-pox, a disease of cattle resembling mild smallpox, renders that person incapable of taking smallpox. He inoculated a number of people with this cow-pox. and afterwards tried to infect them with real smallpox. The results of his experiments were such that he announced cow-pox inoculation, or vaccination, as a preventive of the graver disease.

This belief was subjected to experimental inquiry by a number of physicians, and Jenner's results confirmed by them. The practice of vaccination, therefore, rapidly gained favor in England, and was soon extended to other countries.

Prevalence of Smallpox: In the eighteenth century, 10% of all deaths were caused by smallpox, practically as many as are caused today by tuberculosis. The disease was so common that 60% of the people had it at some time during their lives.

The number of cases of smallpox has steadily decreased since then. From a disease of the eighteenth century killing 300 out of every 100,000 people, it decreased to a disease killing but 25 by the middle of the nineteenth century, but 10 twenty-five years ago, and less than 3 per 100,000 at the opening of the twentieth century. Facts to be cited later indicate that this decrease was due largely to vaccination.

Vaccination and Susceptibility: The liability of the vaccinated and non-vaccinated to contract smallpox differs greatly, the non-vaccinated person being approximately ten times more susceptible to the disease. Thus, in Sheffield, England, during certain years of epidemic, 1.5% of the people who had been previously vaccinated took smallpox. Of the non-vaccinated, 9.7% took it. In an epidemic in Warrington, Eng., 4.4% of the vaccinated children under ten years of age, living in infected houses, took the disease. Of the non-vaccinated children under ten years of age, living in the same houses, 54.5% took it.

Vaccination and Severity of Disease: Vaccination not only reduces one's liability to infection, but it renders the disease less severe, if acquired. During the Sheffield epidemic of 1887 the following table of severity was prepared, the table including all cases of those with the disease:

	Very mild.	Mild.	Severe.	Very severe.
Vaccinated	35.5%	50.0%	13.0%	1.5%
Non-vaccinated	0.00%	17.9%	62.5%	19.5%

Averaging similar statistics from a number of epidemics one obtains the following figures:

	Very mild and mild.	Severe and very severe.
Vaccinated	81.1%	18.9%
Non-vaccinated	24.5%	75.5%

The vaccinated person, therefore, if he does take the disease, runs but a fourth the risk of having it in a dangerous form.

Vaccination and Death-rate: One would expect from this that the death-rate would be less among the vaccinated. Such is

the case. In the London epidemic of 1892, 24% of the non-vaccinated who took the disease died from it. Of the vaccinated who took the disease but 2.2% died, practically a tenth as many.

Dangers from Vaccination: Vaccination is not without its dangers. Any skin wound can be the point of entrance of germs of erysipelas and blood-poisoning. This is as true of a vaccination wound as of any other injury of equal extent; but not more so.

Most alleged cases of death from vaccination are due to coincidence. Deaths from pulmonary hemorrhage, apoplexy, heart disease and other remote causes, have been charged against this practice. It is so easy to draw erroneous conclusions from two things happening at the same time. Statistics are therefore quite unreliable on this point, but they indicate that probably one person dies in every 50,000 to 100,000 primary vaccinations.

This is a very insignificant number when compared with the thousands who would have died of smallpox, but for vaccination. The people of a hundred years ago, familiar with the horrors of smallpox, thought little of this risk.

It is sometimes alleged that tuberculosis, cancer, leprosy, syphilis and other grave diseases are often transferred with vaccine matter. This charge has been most carefully investigated by a number of governments. There is not an authentic case of tuberculosis, cancer or leprosy being so transferred. A few cases of syphilis resulting from arm-to-arm vaccination are, unfortunately, authentic. But syphilis has never resulted from a calf-lymph vaccination and is an impossibility from it, as this disease does not attack, and cannot be transferred to, cattle.

Summary: Vaccination renders a person ten times more resistant than normal to infection with smallpox. If he does acquire the disease he is but a fourth as liable to have it in a severe form and but a tenth as liable to die from it. Vaccination therefore gives him a hundred times his natural chance against death from this disease, if exposed to it.

AN AID TO THE TEACHING OF GEOGRAPHY.

By Edward King,
Wimbledon College, Wimbledon, England.

Perhaps the results of our experience in the teaching of geography will be of assistance to some of your readers, who, of course, have had the same difficulties which my colleagues and I have encountered in dealing with a difficult subject. We found, as others have done, that wall maps, named and coloured in the ordinary way, were not altogether satisfactory, and, therefore, after one or two preparatory experiments had been made, we adopted the following method of constructing the maps for ourselves.

The Educational Supply Association provides a species of dark green linoleum, which is specially prepared for use with blackboard chalk. The outlines have first to be copied from existing maps by means of tracing paper; the back is then rubbed over with white chalk, so that, when placed upon the linoleum —"Cretaline" the makers call it—and the lines retraced with pencil, a delicate chalk impression is left. This line has only to be painted in with a fine paint brush in white oil paint, and the map is ready for use.

So much for construction; and now one word on its advantages. A pupil can be brought out to the map, provided with a piece of chalk, and told by his teacher to trace out the course of this or that river, the line of a mountain range, or the trade route from Liverpool to New Zealand or Hong Kong. Or, again, with a map of England, the railway systems can be shown in various colours, centers of iron, wool, or cotton industries can be appropriately indicated, all with a lucidity, which it is impossible to obtain from the ordinary wall map. Add to this the moral effect produced on the youthful imagination by the sight of the world on Mercator's Projection, six feet by five, upon which he has to display his geographical knowledge; and this, not in the privacy of a written examination, but before a critical set of youngsters of his own age and attainments, each one of whom is thirsting to correct the slightest error made by his classmate at the map, and you have at once an enthusiasm created which, though not all, is at least an important factor in the successful teaching of geography.—*School World.*

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

DEPARTMENT OF METROLOGY, NOTES.

The Smallest Weights and Measures. A correspondent of "The Week's Progress" recently asked: "What is the smallest weight, and when was it adopted?" The reply was: "The smallest measure of weight in use, the grain, has its name from being originally the weight of a grain of wheat," etc.

The editor was evidently not familiar with the metric system, the smallest unit of which is the milligram, equal to 0.015432 grains, or about 1/66 grain. This is, however, by no means the smallest weight. Balances are made and are in use by analysts and assayists which weigh to the 0.01 and even to the 0.001 of a milligram, or about 1/66,000 of a grain.

In linear measure the barleycorn, three of which made an inch, was the shortest of the old English measures. The smallest unit in the metric tables, the millimeter, is 0.03937 inches, but the micron, the unit of the microscopist, is the 1/1,000 part of the millimeter, or 0.00003937 inch. For more delicate work still the 1/100,000 mm. is employed, the millimicron being the 1/1,000,000 part of the millimeter. The late Prof. Rowland constructed an engine for fine rulings that were so accurate that no two adjacent lines have an error so great as 1/2,000,000 of an inch. This means a mechanical precision of not far from 0.01 of a micon, or 0.00001 mm. Prof. Michelson found the red rays of light to have a wave length of not far from 1.5 microns. Such measurements make the grain and barleycorn of our ancestors bungling units. R. P. W.

The Metric System in Cuba. Under date of Feb. 18, 1904, Consul Baehr of Cienfuegos, Cuba, writes: "The metric system of weights and measures is established by law, and is adopted in all transactions at the custom-house, city hall, and in the registry and records of property; in fact, it is compulsory and adhered to in all official acts. In groceries, all solid goods are sold by the ounce and pound, the United States pound being used, as the scales are mostly of American manufacture, a few only being imported from Germany. Liquors are usually sold at wholesale in original packages and at retail by the bottle or fraction of a bottle, the poor people sometimes buying a few cents' worth. The country's products, such as cereals, are sold by the pound or fraction thereof, except that corn, when sold in ears, is sold by the fanega, which is 1,000 ears of corn. Vegetables are generally sold by the pound, the arroba, or 25 pounds. Cabbages and bananas are sold in numbers from one up to 100 or more. Civil engineers and land surveyors employ the metric system throughout their measurements. Mechanics in general make use of English inches as their unit measure."

Biology Notes.

That collodion may be used for detecting transpiration in leaves is learned from the Journal of the Royal Microscopical Society. The surface of the leaf is painted over with collodion. This becomes hard and opalescent where moisture is given off, but remains transparent on dry surfaces. L. M.

The fixation of infusoria may be accomplished in the following simple way, according to P. de Beauchamp: Specimens—vorticella—are mounted under coverglass and exposed to alcohol inside a covered vessel for from one-fourth to three-fourths of an hour, until anæsthetized. They are then fixed by running under sublimate solution (or osmic acid) washing and staining in Picro-carmin, and mounting in glycerine. (Jour. Royal Mic. Soc.)

The preparation of dessicated insects for microscopical mounts is frequently desirable. According to Dr. G. Enderlein (Zoolog. Anz., 1904, p. 479) this may be done by soaking in water 8-10 parts, to which is added 1 part moderately strong KOH solution; in case of delicate insects this is to be used more dilute. Objects are to be left 10 minutes to 1 hour—until natural form is regained. Then they are to be washed in water and dehydrated in 96% alcohol, where they may be kept, or further dehydrated, cleared in cedar oil and mounted in balsam.

A method of demonstrating the evacuation of the pulsating vacuole in paramoecia is given by Dr. H. S. Jennings in Zool. Anzeig., June 14, 1904. The animals are mounted in water that is charged with finely ground India ink (stick India ink). Drawing off some of the water will allow the coverglass to settle on the animals and thus hold them down. At the side of animals lying in proper position the bright drop can be seen extruded in the dark ink, but it is soon swept away by the cilia. After much patient watching it may be seen in animals moving or resting, but not held by the coverglass.

In the study of stem tissues, for elementary classes, a simple method for demonstrating the upward course of water and downward flow of sap is the following: A geranium stem is placed right side up in an old solution of haematoxylin and left for at least 24 to 36 hours. Another is placed up-side-down in eosin. When sectioned (by hand) only the xylem cells are stained in the former, while in the latter phloem, cambium and xylem are stained. When the same stem in the first part of the experiment is reversed and placed in the second stain the result is quite satisfactory. More permanent stains might be used. Lenore Conover.

News Notes.

The following items are taken from the Journal of the Royal Microscopical Society (1903-1904):

Bréal and others have found that cold produces a reducing sugar in potatoes. This, no doubt, accounts for the sweet taste of partly frozen potatoes.

The new fresh water medusa in Lake Tanganyika is now thought to be identical with the one formerly discovered by Boem in 1883.

"Moulds and bacteria absorb soluble arsenic, selenium, tellurium, etc., giving out a characteristic odor." In this we have a "biological test for the presence of arsenic." L. M.

A practical application of X-rays has been made by Raphael Dubois in finding pearl in pearl-oysters. This is thought to be an important discovery in pearl industries, as the examination does not injure the animals.

In an epidemic of field mice a germ has been found that can be isolated and spread among rats. "Such cultures have been used successfully in the destruction of rats on farms, in warehouses, etc., and even in a large town like Odessa." The virulence of the organism is kept up with difficulty.

The theory that starch grains may exercise a static function in plant cells orienting toward gravity when a plant has been displaced has been supported by experiments by France Darwin. If the theory were true it was assumed that causing the seedlings to vibrate on a tuning fork would increase the stimulus of starch-grain impact on the wall of protoplasm. The result was that 44% more curvatures took place than in seedlings not vibrated.

That grafting can prolong the life of an annual plant is maintained by the French writer M. L. Daniel. He grafted an herbaceous plant (Solanum pubigerum) on an annual with the above effect. He further maintains that grafting enables one to produce flowers and fruit out of the usual season. In another case this author observed a hybrid pear branch that had grown from a protuberance at the level of the cushion, but was covered by cortex of the stock.

LIFE PRODUCED ARTIFICIALLY.

Prof. Jacques Loeb, head of the department of physiology at the University of California, announces that he has at last been able to create life by artificial means. The great physiologist has long been experimenting with the eggs of the sea urchin, one of the lowest forms of animal life, and now by a process including frequent use of hypertonic sea water, ending finally in a bathing of the eggs in an ethylacetate solution, the same development has been found to take place as in eggs fertilized naturally.

This is one of the greatest forward steps ever taken by science, and its far-reaching effects can be immediately appreciated. Prof. Loeb having thus artificially produced life in the low form of the sea urchin, says that he will attack the problem of endeavoring to accomplish the same result in more complex organisms. He now has hopes that he will be able, guided by the knowledge gained in the care of the sea urchins, to solve the great problem of the source of life in the higher animals, and if sea urchins can be propagated artificially, why not mammals?—*School Journal.*

NOTES ON GEOMETRY.

By G. W. Greenwood,
McKendree College, Lebanon, Ill.

I. Dependence of Plane Geometry Upon Solid Geometry.

Possibly many teachers imagine that in the study of plane geometry we are not concerned with space of three dimensions. Yet we assume—tacitly, I am sorry to say—that figures may be moved without altering their form and size, if I may thus crudely express myself. When we consider two triangles having two sides and the included angle of one congruent respectively to two sides and the included angle of the other, it is customary to draw two triangles which may be brought into coincidence by sliding one of them or rotating it in its plane, or both, and then we apply our results without comment to triangles which cannot be brought into coincidence without turning one of them over; for example, in proving a point in the perpendicular bisector of a segment to be equi-distant from its extremities.

Plane geometry consists of the relative forms and magnitudes of plane figures, though no two of the figures need lie in the same plane.

If two planes cut each other, their intersection is a straight line.

This is usually the first proposition in solid geometry; in demonstrating it we *take* two points common to the planes without any apology for assuming that two such points exist. But aside from this tacit assumption, in texts where some of the proofs in plane geometry depend on folding part of the plane on some line as an axis, and in discussion of axial symmetry, this proposition has already been assumed, and the proof of it in solid geometry is rather tardy.

II. A Geometrical Fallacy.

If two polygons are mutually equilateral and mutually equiangular, they are congruent.

There are some elementary geometries in which this proposition occurs, with the explanation that they can *evidently* be made to coincide. Unfortunately, the proposition is *not true.*

Considering polygons as ordinarily defined, take an equilateral polygon, A B C D E F . . ., of not fewer than eight sides, such that the angles at B, C, D, E are congruent to each other, but not congruent to any of the remaining angles. Now, take a polygon congruent to this one, and call it A′ B′ C′ D′ E′ F′ . . ., where, of course, A is congruent to A′, B to B′, and so on. Join the mid point, M, of AB to the mid point, N, of CD; it can be seen that MN is parallel to BC since the angles at B and C are congruent. In like manner join the mid point, R, of B′ C′ to the mid point, S, of D′ E′; it can also be seen that R S is parallel to C D. Now it follows that in the polygons, A M N D E F . . ., A′ B′ R S E′ F′ . . ., the angles A, M, N, . . . are congruent, respectively, to the angles A′ B′ R, . . .; and it is easily seen that the sides A M, M N, N D, . . , are congruent, respectively, to the sides B′ R, R S, S E′ . . .. Hence the polygons are mutually equiangular and mutually equilateral, but evidently, in general, *not congruent.*

III. What Is an Angle?

What is an angle? Sometimes we are told that it is a figure formed by two indefinite half-lines issuing from a common point; then follows a discussion concerning another half-line turning from one arm to the other, with the observation that there are *two* ways of rotating the moving half-line in passing from one to the other, and we are told that what at first was defined as an angle turns out to be *two* angles. This is more like magic than logic. But it should be apparent to every one that there are an *infinite* number of rotations which will bring the moving half-line from coincidence with the first arm into coincidence with the second.

It is then sometimes stated that the angle is greater when the *amount of turning* is greater, though how we are to determine the amount of turning is not mentioned; probably by looking at the picture—a very prevalent, but unconscious, basis of reasoning in nearly all texts.

We are then told that of the two angles formed by the two arms we will understand the smaller to be meant unless the contrary is stated. When we come to the sum of two adjacent angles, *i. e.*, the angle formed by their exterior arms, we find that in accordance with the preceding restriction the sum of two angles, each of 150°, would be 60°, since the reflex angle has been excluded, and the author neglects to remove the restriction. That geometry students often become good lawyers is not the fault of their teachers!

In another text we find angles compared by placing them so that they have the same vertex and a common arm, and lie on the *same side* of this arm. Passing over this quiet introduction of the statement that there are two sides to a half line, I would ask, how are we to perform that operation with reflex angles? And in another text in common use I find the terms "greater" and "less" applied to angles without any preliminary explanation whatever.

In another, we are to notice by looking at the figure that the lines start out from the vertex in *different directions,* and are informed that when two *lines* meet in this way they are said to form *an angle.* Considering all possible combinations we will find that two intersecting, but non-coincident, lines form *twelve angles* instead of one angle.

What is an angle?

If two adjacent angles are supplementary, their exterior sides lie in the same straight line.

This is solemnly proved in several texts, although it is merely another form of the definition of supplementary adjacent angles; it is about as logical as would be a proposition that if the opposite sides of a quadrilateral are parallel, it is a parallelogram.

NOTES.

On March 4, Dr. Paul Carus, of Chicago, gave an address on "The a priori of Mathematics" before the Mathematical Club. Dr. Carus is the editor of "The Monist," managing editor of the Open Court Publishing Company, and is a German scholar of note. His address was much enjoyed by the students of mathematics and philosophy.

At the regular meeting of the Mathematical Club on March 25, the following papers were presented:

1. Miss Neta Hannum, "Beginnings of Mathematics."

2. Mr. George Sype, "Mathematics in Elementary and Secondary Schools."

The following courses in mathematics are to be given in the University of Illinois Summer Session, June 12 to August 11: By Prof. H. L. Rietz, Courses in Advanced Algebra, Solid Geometry and Differential Equations. By Dr. H. L. Coar, courses in Plane Geometry, Analytical Geometry and Integral Calculus. By Mr. E. W. Ponzer, courses in Differential Calculus and Descriptive Geometry. By Mr. E. B. Lytle, courses in Elementary Algebra and Trigonometry.

PERSONAL NOTES.

A paper on "The Effect of Pressure Upon the Resistance of Selenium Cells," by Mr. F. C. Brown, a graduate student in physics, was read at the February meeting of the American Physical Society.

Dr. Joel Stebbins, Assistant Professor of Astronomy, has been given a leave of absence for next summer to go to Labrador with the Lick Observatory eclipse expedition.

Mr. J. H. Dickey, '98, is Professor of Mathematics at the State Normal School of South Dakota, Springfield, S. D. E. B. LYTLE.

SCIENCE NOTES.

It has been found that steel containing 45 per cent of nickel possesses the same coefficient of thermal expansion as glass, with the result that nickel-steel wires of this constitution can be used for sealing into incandescent lamps, instead of the platinum wires heretofore used.

Several manufacturers of incandescent lamps are now using this alloy of nickel and iron, under the name of *platinite;* it has been estimated that by this means a ton of platinum will be saved per annum.

ELECTRIFICATION IN ENGLAND.

"Every railway in the United Kingdom," says the *London Sphere,* "is now considering the question of electrification. The rapid spread of the electric trolley-car system all over the country, connecting town with town and village with village, has affected the suburban receipts of several railways. Two great lines are hoping to postpone the day of electrification by the adoption of 'decapods,' ten-wheel tank engines capable of hauling greatfer loads than any locomotive hitherto built for suburban traffic."

The astronomical and other scientific journals are now publishing maps and detailed information concerning the total solar eclipse of August 29, next. The *Bulletin de la Société Belge D'Astronomie* of Brussels is early in the field with an excellent general map of the region of totality and a detailed map on a large scale of the line of totality across Spain, together with a good general account of the six total solar eclipses of this century

visible in Europe. Spain is rapidly becoming one of the tourist regions of the world and this exceptional opportunity to see so rare and impressive a phenomenon as a total solar eclipse will, it is thought, stimulate Spanish travel considerably during the coming summer.

Although manifest benefits have been derived from the use of X-rays, yet their use is not without some element of danger, says Dr. Holland. "The most recent case of this kind is one that has occurred in America. Dr. Weigel, of Rochester, N. Y., one of the most skillful and enthusiastic of American surgeons who used X-rays, was in England one year ago. He was then suffering very badly from chronic dermatitis of the hands. A short time ago cancer supervened, and on October 11 it was found necessary to amputate the right hand at the wrist, and to remove the first, second, and third fingers, and a portion of the metacarpus of the left hand. One may expose one's hands to the rays with impunity for years, but the risk is great, and I have no doubt that the effect of these constant exposures is, so to speak, cumulative, and that, as time goes on, the hands get more and more 'tender' to the rays. It matters not very much whether the effects produced are caused by the X-rays themselves, or some other agent; whatever it is, an active X-ray tube is a danger to the operator, and one cannot be too careful in guarding oneself against this danger. At the same time, certain articles in the daily press are calculated to do harm, as many of the general public reading them may be led to conclude that there is danger of chronic dermatitis and cancer being caused by having an X-ray examination made, or by being treated with X-rays. Some people, on this account, may be led to refuse either to be examined or treated by the rays when either the one or the other may be necessary. It may be definitely stated that no harm whatever can follow a properly conducted X-ray examination, and I think one is also justified in saying that the treatment by X-rays in skilled hands is also harmless." —*Scientific American Supplement.*

NITROGEN IN RAIN WATER.

Meteorologists generally consider that they have done their duty by the rainfall when they measure the quantity and the time of occurrence, either daily or hourly. But the students of agriculture and forestry, those who drink rain water, and those who study the physics of the atmosphere are all alike interested in the chemical composition of the rain water. The time must come when chemical analysis of the rain water will be made systematically at a large number of carefully selected rainfall stations. It is hardly desirable that any of these should be located in large cities, since the rain that falls there has so little influence on agriculture or water supply. The most important stations will be those in the open country, whether inland or near the seacoast, and especially those at mountain tops and base stations. The importance of this subject to agriculture may be estimated from a statement by Mr. H. Ingle, in charge of the chemical work of the Department of Agriculture of the government of the Trans-

vaal. According to "Nature," Mr. Ingle finds that Transvaal soils are deficient in nitrogen, but that the receipt of combined nitrogen from the atmosphere, namely, nitrates, ammonia, etc., is much larger than in England. Thus, at Rothamsted, the average annual receipt of atmospheric nitrogen in the rain water amounts to 4.75 pounds annually, whereas in February and March, 1904, in Pretoria, the rainfall brought down about two pounds per acre. As the normal rainfall for these two months is seven inches, while the annual rainfall is thirty inches, it may, therefore, be estimated that the annual quantity of nitrogen brought down by the rain at Pretoria is at least eight and possibly ten pounds per acre, or twice as much as received at Rothamsted in England.

By analogy we may anticipate that the varying proportions of nitrogen brought down in different portions of the United States by the rainfall may be an important consideration in explaining the agricultural peculiarities of special regions.—*Weather Review.*

Report of Meetings.

REPORT OF THE FORTY-FIRST MEETING OF THE EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The meeting was held in the English High School, Boston, and also at the Massachusetts Institute of Technology.

After the annual reports of the Secretary and Treasurer, the Committee on Current Events in Physics presented its report as follows:

Among the most important scientific inventions and subjects which have come to the public notice the last few months are the improvements in and applications of wireless telegraphy; the extension of our knowledge of radio-active substances; the Tantalum Lamp; and the Pollak-Virag telegraph instrument.

Experiment has shown that it is not of paramount importance to have wireless telegraphy capable of transmission over a distance of 3,000 miles. A working radius of five hundred miles would suffice to patrol the whole Atlantic, with stations in the Azores, Cape Verde Islands, Bermuda, and the Windward Islands. The other great areas could probably be similarly covered. Attention is now being given to increasing the power of the steamship wireless outfits. It is hoped that experiment will develop more power in the short waves, thus doing away with the necessity of the long antennae—so difficult to set up at sea. The New York Central is to equip the Twentieth Century limited express with a wireless service so that passengers may receive or send messages whether the train is standing still or running at the rate of ninety miles an hour. The engine cab will also be fitted with a receiver to intercept warning signals, so that it will work independently of the regular telegraph system and be serviceable when, from storms or any other cause, the regular telegraph system is out of order.

Evidence is accumulating to show that radio-activity has much to do

in explaining physical and chemical phenomena of the heavenly bodies, the earth's interior, etc. The spectra of the radium emanations having been identified in the sun, the stars, and in substance originating deep in the earth, as hot springs and volcanic ejecta.

The Tantalum lamp is the ordinary glow lamp, fitted with a filament of Tantalum, a rare element belonging to the Bismuth and Antimony group, discovered about 1800. It is a very refractory metal, heavy, malleable, ductile, strong as steel, more resistant than Platinum to heat and chemical reagents. It has a higher specific resistance than Platinum and a lower coefficient of expansion, and works steadily in the lamp at two watts per candle power. The ore from which the metal is obtained is said to be common enough to allow cheapness to be combined with durability.

The Pollak-Virag Telegraph instrument, it is claimed, can transmit messages and write them in legible handwriting at the rate of 40,000 words an hour; the fastest instrument at present the (Wheatstone automatic) transmitting at the rate of 25,000 words an hour, and using the Morse alphabet and requiring to be translated into ordinary language which can be done only at writing speed. In the Pollak-Virag System the message to be transmitted is converted into dots and dashes by a typewriter-like machine or perforator which correspond in electrical impulses to the form of letters. By passing this slip over a series of cylinders, electrical waves find their way through the prepared holes and by varying the strength of the line current affect attraction and repulsion of a magnet at the receiving end of the line. This magnet bears a mirror which reflects a beam of light upon a swiftly moving strip of photographic sensitive paper; the mirror has been given two motions by the magnet, one in a vertical, and one in a horizontal plane, and the combination of these reproduce the handwriting of the message which is traced by the reflected beam of light on the sensitive paper. The light beam traces the message at the rate of fifteen words a second. The developing and fixing of the photograph takes ten seconds when the message in the handwriting of the sender is ready for delivery.

Of interest to physicists is the mounting of the great Common reflecting telescope now being put in position on the Harvard Observatory grounds. The instrument, instead of being supported by a pier of masonry or an iron column, is supported by a cylindrical steel float eighteen feet long and eight feet in diameter, which is partially submerged in a concrete tank filled with water and so ballasted that the axis points toward the celestial pole. Delicate pivots on the ends of the float serve to steady it in this position allowing it to turn freely on the axis relieved of nearly the entire weight by the buoyant effect of the water.

C. S. Griswold, *Chairman.*

New Apparatus.

Mr. Andrews, for the committee on new apparatus, showed the Association a liquid refraction tank manufactured by the Central Scientific Company of Chicago. He also showed a Juno motor manufactured by the Page Electric Company of Worcester at a cost of $5.00. This he tested

by means of pulleys, a balance, and a weight and obtained the following data:

Input.		*Output.*	
Current,	1.4 amp.	Speed,	1950 revol. a min.
E. M. F.,	60.0 volts.	Circum. of pulley,	4.9 cm.
Power,	8.4 watts.	Total distance,	9555 cm. a min.
		Bal. record No. 1,	220 gm.
		Bal. record No. 2,	20 gm.
		Work done,	1930110.0 gm. cms. a min.
		Work done,	32168.5 gm. cms. a sec.
		One watt equals	10190.0 gm. cms. a sec.
Efficiency, 37 per cent.		Power obtained 3.1 watts.	

REPORT OF THE COMMITTEE ON MAGAZINE LITERATURE,
NOV. 1904—FEB., 1905.

Mechanics and Engineering.

A Novel Adaptation of the Archimedean Screw. Sci. Am., Dec. 24, 1904.

Application of the Gas Engine to the Locomotive and Steamship. Sci. Am. Sup., Feb. 4, 1905.

Some Facts Concerning Marine Turbines Obtained from Trials by the English Navy. Sci. Am., Dec. 24, 1904.

Some Refinements of Mechanical Science. Sci. Am. Sup., Jan. 21, 1905.

The Largest Water Turbine in the World. Sci. Am., Jan. 7, 1905.

The Testing of Steam Engines. H. R. SANKEY AND C. H. WINGFIELD. Eng. Mag., Nov., 1904.

(Illustrated equipment and work of a noted laboratory.)

Light.

Color Photography by a New Method. Sci. Am. Sup., Dec. 10, 1904.

New Researches on Photographic Photometry. Sci. Am., Dec. 17, 1904.

On the Modern Reflecting Telescope and the Making and Testing of Optical Mirrors. G. W. RITCHIE. (Technical, but portions are of general interest. Illustrated.) Sci. Am. Sup., Dec. 24, 31, 1904; Jan. 7, 14, 21, 28, 1905.

Electricity.

A New Form of Apparatus for the Electrolysis of Water. Sci. Am., Dec. 24, 1904.

A Tentative Theory of Thermo-Electric Action. EDWIN H. HALL. Sci. Am., Jan. 20, 1905.

(Electricity is looked at as perhaps something like a gas rather than as an incomprehensible fluid.)

Do the Rails of the Electric Street Railway Return the Current to the Generating Station, or Simply Act as a Ground? Sci. Am. Sup., Nov. 12, 1904.

Experimental Electrochemistry. N. MONROE HOPKINS, Sci. Am. Sup., Dec. 3, 17, 31, 1904; Jan. 14, 28; Feb. 11, 25, 1905.

(To be continued. Well illustrated and valuable series. Deals largely with the ionic theory.)

Fog Dispersion by Electricity. Sci. Am., Feb. 11, 1905. Elect. World, Nov. 26, 1904.

Radium and Its Products. WILLIAM RAMSAY. Harper's Mag., Dec., 1904.

(The transmutation of radium to helium and other elements.)

Pioneer Work in High Tension Electric Power Transmission. P. N. NUNN. Cassier's Mag., January, 1905.

(Finely illustrated. Good material for lantern slides.)

Siemens and Halske Printing Telegraph or Telecryptograph. Sci. Am. Sup., Nov. 19, 1904.

Simultaneous-Telegraphy and Telephony. JOSEPH HOLLOS. Sci. Am. Sup., Dec. 24, 1904.

SIR OLIVER LODGE on Lightning Conductors. Sci. Am. Sup., Jan. 7, 1905.

Thawing out Frozen Water Pipes Electrically. WM. MAVER, JR. Cassier's Mag., Nov., 1904.

The Electric Theory of Metallic Conduction. Elect. World, Dec. 3, 1904.

The New York Central Equipment. Elect. World, Nov. 26, 1904.

(Reasons adduced for choosing the direct current instead of an alternating current equipment.)

The Testing of Lightning Rods. Sci. Am. Sup., Nov. 19, 1904.

The Electrical Testing Laboratories. CLAYTON H. SHARP. Elect. World, Jan. 7, 14, 21, 1905.

(Illustrated. Describes buildings and apparatus for all kinds of accurate testing.)

Why Steam Locomotives must be Replaced by Electric Locomotives for the Heaviest Freight Service. H. WARD LEONARD. Elect. World, Jan. 7, 1905.

Electric Waves. A. D. COLE. Elect. World, Jan. 7, 1905.

Wireless Telegraphy Experiments at the Eiffel Tower. EMILE GUAVINI. Sci. Am. Sup., Feb. 25, 1905. Illustrated.

Miscellaneous.

Biographical Sketch of Henri Becquerèl, with a Brief Account of his Discoveries. Sci. Am., Dec. 3, 1904.

Galileo. EDWARD S. HOLDEN. Pop. Sci. Mo., Jan., Feb., 1905.

(To be continued. A vivid picture of the man and his work.)

Some New Cooper-Hewitt Inventions. Sci. Am., Feb. 11, 1905.

The Fundamental Concepts of Physical Science. E. L. NICHOLS. Pop. Sci. Mo., Nov., 1904.

(Address at the International Congress of Arts and Sciences, St. Louis.)

The N-Rays: Arguments against their Existence. R. N. WOOD.

A Reply to Professor Wood: Explanations and Statements Concerning N-Rays. W. R. BLONDOT. Sci. Am. Sup., Dec. 17, 1904.

The Personalities of Professor and Madame Curie. Sci. Am., Nov. 5, 1904.

WILLIAM F. RICE, *Chairman.*

ELECTION OF OFFICERS.

The election of officers resulted in the choice of the following:

President, Irving O. Palmer, Newton.

Vice-President, C. H. Andrews, Worcester.

Secretary, Sidney Peterson, Boston.

Treasurer, Arthur H. Berry, Providence.

Executive Committee,: President, Vice-President, Secretary and Treasurer, *ex-officio;* G. A. Cowen, Boston; Fred R. Miller, Boston, and W. F. Rice, Boston.

Dr. John F. Woodhull showed the "Progressive Electro-Dynamic equipment,"* in which many were interested at the last meeting.

DEMONSTRATION OF THE PROGRESSIVE ELECTRO-DYNAMIC EQUIPMENT.

Dr. Woodhull showed the Weston Ammeter calibrated as ammeter voltmeter, and millivoltmeter. He connected two wires to this and by heating them at their junction forced the index across the scale, registering one twenty-five thousandth of a volt.

The Porter storage battery was then shown. It weighs forty pounds, is composed of six cells, gives twelve volts, and is good for twenty-five ampere hours. With it a piece of number twenty-four German silver wire eighteen inches long was heated to a bright red heat.

Experiments illustrating reaction between a current and a magnetic pole and "Gore's railway" were performed with parts of the equipment.

Professor Woodhull then built up the Evans machine step by step, showing the essential features of motors, direct current and alternating current dynamos with series, shunt, and compound windings of fields. The spools of the equipment were exhibited as induction coils and as means for showing the attraction and repulsion of parallel currents. The winding of the spools were such as to develop the greatest possible magnetism in the iron cores. The number of turns of wire were stamped on the spools, and binding posts on them served for various kinds of connections. The field spools were provided with three different sets of pole pieces for a great variety of purposes. With one set of flat pole pieces, Faraday's disk dynamo and disk motor were illustrated. By means of the damping effect upon a pendulum, the use of slotted armatures to prevent heating by eddy currents was brought out.

The millivoltmeter connected to the fields while various pole pieces were put on and off was shown to be an exceedingly sensitive galvanometer. The motor was made to revolve an aluminum disk which caused a heavy bar magnet suspended over it to revolve. When the armature of this motor was given a turn by hand, it generated a current as a dynamo and rang a bell. With a drive motor attached, this dynamo lighted five twenty volt lamps. When the machine was connected as a shunt wound dynamo with compound winding on the fields and self-exciting, it maintains eighteen volts with a load of ten amperes. Another armature without commutators was slipped in and the machine lighted the same five lamps with an alternating current. This was stepped up by a ring transformer so as to light a fifty volt lamp.

The two phase current was illustrated and a squirrel cage induction motor was operated.

The morning session was adjourned for lunch and to see the excellent

*Manufactured by H. J. Evans, Wausau, Wis.

collection of lantern slides which Mr. Miller had made and kindly laid out for inspection. His new work shop, dark room, electric motor-dynamo converter, and switchboard were also inspected.

Afternoon Session.

After luncheon at the Technology Club, the Association met in the Lowell Building, M. I. T., where it was addresed by Prof. H. E. Clifford on the subject of

Alternating Currents and Their Place in a High School Course.

Professor Clifford said that it is desirable to have something definite in the high school course in regard to alternating currents. It is not too early to begin the study of the fundamental principles of these in the high school.

The direct current laws may easily be obtained by current from batteries. Industrially the alternating current is very largely used, so is it not best to begin the study with alternating currents instead of with the direct current? The laws of alternating currents are not so complicated that they cannot be understood by the youthful mind. The apparatus side, the equipment, it is true, is vital. If the high school has a good shop, and every school should have such, the teacher can get up the apparatus necessary for the study and demonstration of alternating currents at a moderate expense.

It is Professor Clifford's belief that in any course of physics the fundamental instruction should be by class room work which should be made more vital by the laboratory. The fundamental principles cannot be given in the laboratory. The class room comes first in usefulness and efficiency in instilling the fundamental ideas, and the laboratory second. A well illustrated course of lectures is more valuable than a well equipped laboratory. Engineers have given this as their belief. Ram home the principles qualitatively rather than try for accurate quantitative work with poor apparatus. It is best to spend money for elaborate lecture apparatus and get the simplest individual laboratory apparatus.

The laboratory work should be qualitative not quantitative. It should aim at accuracy in observation, not accuracy in measurement. In high school physics error in measurement is unimportant. True quantitative work, that is of a precision from .1 or .2 of one per cent. is the work of the university, not of the high school. The quantitative side of the work should not be emphasized because it gives to the pupil a wrong conception concerning true accuracy in physical measurements. The work should not be slipshod, but should be as accurate as the apparatus will allow. At the Massachusetts Institute of Technology it has been noted that students have a false notion concerning their work in the high school. They believe that they have done accurate work, whereas their work has been far from it. Too much stress cannot be put on the qualitative side. The explanation of every day phenomena is the true function of high school physics. Recent text-books are lacking in this regard and omit the necessary why and wherefore. They also emphasize too strongly the quantitative side.

Professor Clifford then showed the apparatus which he uses to illus-

trate to his classes some of the phenomena of polyphase currents. It seemed inexpensive and was mostly made in the department.

The general idea of generating a current is first to produce a magnetic field and then to rotate a coil or a combination of coils in this field. A set of fingers as brushes may make contact in a number of combinations which are brought to a switch board. Connected with this is a set of three voltmeters, which, as galvanometers, show the various phases of the current.

First, a simple alternating current was generated by rotating a single coil between the two poles. A couple of slip rings connect the two ends of the coil and carry the current from the coil by conductors to the galvanometer. The needle of this galvanometer vibrated first to the left and then to the right, coming to zero, when it should, with the coil in the vertical plane. By the graphical method the wave form of the alternating current may be shown to advantage.

Next, the two phase current was introduced with two coils instead of one. The coils should be at right angles to each other and the terminals of each coil should be attached to a slip ring, each one of which is in contact with a brush. With these two coils there are two currents produced, as shown by the deflections of the two galvanometers which are now in circuit. When one coil gives its maximum deflection, the other gives no deflection. If these two coils are in the same circuit, the fluctuations of the needle are not as large as with one coil. This is made clear by graphical representation.

If in the one coil armature the coil is connected with a commutator instead of the two slip rings, the slits of the commutator being parallel to the plane of the coil, it was found that the current was entirely in one direction, the needle going to maximum deflection and then to zero. This, by graphical representation, gives waves on one side only. From this should be built up the idea of conjugation with two coils and four part commutator, which will cause the needle of the galvanometer to fluctuate less and not come to zero.

The next step is the development of three phase currents. In this there were three sets of coils. When each pair of slip rings which join the ends of the coils are connected with a galvanometer, it is seen that when two currents are of equal strength, the third is equal to their sum and in opposite direction, and also, that when one needle is at zero, the other two are opposite and equal. By a careful study in the lecture room or the laboratory of these readings and of the graphical representation of them, the pupils will get a very good conception of this special type of alternating currents. Instead of having six slip rings, three may be used by joining those three terminals of the coils which are at the same time zero. This gives the "Y system." A coil thus arranged will give the same deflections as the six slip-ring coil.

The study of the direct current may be developed in the same way, with a commutator in place of the slip rings.

Next, the rotary field motors were introduced. In these the combination of north and south poles are made to travel along, the drag of the field causing the armature to revolve. This was illustrated by the squirrel

cage armature, which requires no commutator and is used in manufactures where sparking is dangerous. The next type was the squirrel cage with a laminated iron core which concentrates the field between the bars, thus increasing the power.

Professor Clifford then showed the three phase arc light, the three carbons of which were supplied by three conductors which carry three phase currents. These constantly change at the rate of sixty times a second, as was shown by rotating a slotted disc in front of the light by means of an induction motor, whose slip could be varied.

In closing, Professor Clifford said that he did not believe in the too great emphasis of the industrial side. But he believed that alternating currents should be studied because they are used on every hand, whereas the direct current is becoming less important as a means of transmitting power, and will be of less and less consequence for such work because of rectifiers such as the mercury vapor lamp. Here, then, is a distinct field which can be covered in a moderate time and at a moderate expense.

A rising vote of thanks was given Professor Clifford at the close of his talk.

The meeting adjourned for the inspection of the Lowell Laboratories, which were kindly opened for the Association.

SIDNEY PETERSON, *Secretary.*

ASSOCIATION OF OHIO TEACHERS OF MATHEMATICS AND SCIENCE.

The second annual meeting of the Association of Ohio Teachers of Mathematics and Science was held at the Ohio State University, Columbus, March 25, 1905. In the morning the Mathematical and Science Sections met together. The sections held separate meetings in the afternoon. President Howe presided at the general sessions and that of the mathematical section. Professor McPherson, Ohio State University, was elected chairman of the science section.

Several proposed amendments to the constitution were adopted. The annual dues were made one dollar and fifty cents. SCHOOL SCIENCE AND MATHEMATICS is to be sent to all paid up members without charge.

The following officers were elected: President, William McPherson, Ohio State University, Columbus; Vice-President, Franklin T. Jones, University School, Cleveland; Secretary, Thomas E. McKinney, Marietta College, Marietta.

The program was as follows:

MATHEMATICAL SECTION.

"What shall be done with the high school pupil who is unable to master demonstrative geometry? Shall students who fail only in mathematics be permitted to graduate from the high school?" by T. L. Feeney, Miami University.

The difficulty in mastering demonstrative geometry is usually overestimated. Failures are generally due to bad teaching. Beginners not seeing the need of any demonstration of (to them) self-evident propositions, fre-

quently become discouraged and never really overcome their initial difficulty. The distaste of many girls for geometry is probably due to their zeal to have a good lesson, which leads them to memorize demonstrations without really understanding them until the subject palls. These cases are to be avoided by better methods of teaching. In particular, it has been found very effective in giving beginners an insight into the purpose of a demonstration and in creating a taste for geometry, not to insist on a demonstration until the pupils themselves see its need. Leaving aside these cases, due to defective instruction, in the very few remaining instances students failing in mathematics, but ranking high in all other studies, should be graduated from the high school.

"How to Teach Rational Geometry," by George Bruce Halsted, Kenyon College.

By the assignment of the entire mathematical program to the afternoon Dr. Halsted's time was so limited that only the introductory part of his paper was presented, which dealt with how *not* to teach rational geometry. Pointing out the importance of drawing and other geometrical exercises in helping to clear notions of geometry, he passed on to demonstrative geometry and reviewed certain axioms and definitions involving the idea "the shortest distance between two points" and appearing in well known texts. Analyzing this phrase, "The shortest distance between two points," it was found to presuppose the vast complex of assumptions necessary for measurements and, in particular, the theorem Euclid L. 20: "Any two sides of a triangle are together greater than the third side;" also, the possibility of measuring all kinds of lines that can be drawn anywhere in space. The length of a curve is defined by the aggregate formed by the lengths of a proper sequence of inscribed polygons. This definition in ordinary cases creates for the curve a length; but in case the aggregate is not convergent the curve is regarded as not rectifiable. It has no length. The phrase in question as applied to the totality of lines joining two points is, therefore, without meaning. Further, the very existence of a minimum is itself an assumption. In the Rumanneau plane with every point is another such that between them is an infinity of shortest lines. These difficulties are so serious, so obvious, that it is little short of a miracle that this absurd crudity has not long ago been ejected from elementary demonstrative geometry. When, therefore, authors give as their definition of a straight, "A straight line is a line which is the shortest path between any two of its points," they pass through and beyond Euclid's elements to give us his simplest element; they institute a comparison not only with circular arcs, but also with all curves known and unknown; they presuppose a foreknowledge of all lines in a definition of the simplest line. Is it still needful to say this is grossly bad logic, bad pedagogy, bad mathematics.

At the close of Dr. Halsted's paper the following resolution was offered: Resolved, That in teaching demonstrative geometry we will not use the phrase, "A straight line is the shortest distance or path between two points;" or the phrase, "The shortest distance between two points is measured on the straight line joining them." This resolution was referred to a committee composed of Drs. Halsted, Howe and Wilson, to report at the next meeting.

W. H. Wilson, Wooster University, exhibited and explained a simple piece of apparatus which he had found helpful in giving students clear notions of the elementary trigonometric functions and of the changes in sign and numerical value they undergo with a varying angle.

"The Teaching of Elementary Algebra," by Theodore M. Focke, Case School of Applied Science.

This paper was a discussion of some of the failings of most high school graduates.

Inaccuracy was stated to be the greatest mathematical fault at the present time. It was thought to be due to the practice of giving large credit for principle on all questions in examination. There should be, in any examination, some problems for which correct answers are required and *no* credit should be given unless they are correct.

Attention was called to the fact that first principles were not reviewed sufficiently, and that, as a result, algebra soon becomes a collection of rules and all work mechanical. Algebraic demonstration should be given as much attention as those of geometry and should be just as thoroughly mastered.

SCIENCE SECTION.

"How is Chemistry Best Taught to Beginners? A Practical Demonstration," by C. F. Maberry, Case School of Applied Science.

Professor Maberry gave an object lesson to a class of six boys, twelve years of age, who had no previous acquaintance with chemistry, with the purpose of explaining how readily young pupils may be taught the habit of correct observation and the method of inductive reasoning. Incidentally it was shown that simple and inexpensive apparatus and materials easily obtainable are all that is necessary in such teaching. The demonstration was also an attempt to show that the excessive time and energy now devoted to studies that are solely a cultivation of the memory should be applied in part to correct methods of observation and reasoning.

"Some Essentials of a Laboratory Course in Physics," by R. O. Austin, Central High School, Columbus.

Professor Austin emphasized the following essentials: First, That all members of a laboratory section work on the same exercise at the same time. Second, That apparatus be so duplicated that the first may be carried out. To this end less illustrative and more student apparatus should be purchased. Third, That the original note book entries be left with the teacher for correction as the pupils leave the room. Fourth, That results after correction by teacher and pupil be carefully entered in critical note books. Fifth, That graphic representation of results be made whenever possible. The teacher may give additional data for practice in curve tracing. Sixth, That the laboratory be in complete readiness before the pupils enter. Seventh, That with instruments of precision practice be sufficient to insure facility in use.

It was shown that the first and second can be accomplished at a much less cost than commonly supposed and in support of this position some apparatus, part of original design, was exhibited.

THOMAS E. MCKINNEY, *Secretary.*

SCIENCE AND MATHEMATICAL SOCIETIES.

Under this heading is published each month the name and officers of such societies as furnish this information.

Central Association of Science and Mathematics Teachers.

President, Otis W. Caldwell, State Normal School, Charleston, Ill.
Secretary, Chas. M. Turton, 440 Kenwood Terrace, Chicago, Ill.
Treasurer, E. Marsh Williams, High School, La Grange, Ill.
Annual meeting Friday and Saturday immediately following Thanksgiving.

Chicago Center, C. A. S. and M. T.

President, W. C. Hawthorne, Central Y. M. C. A., Chicago.
Vice-President, P. B. Woodworth, Lewis Institute, Chicago.
Secretary, C. E. Osborne, High School, Oak Park, Ill.

North-Eastern Ohio Center, C. A. S. and M. T.

President, Franklin T. Jones, University School, Cleveland.
Vice-President, Miss Winona A. Hughes, High School, Mansfield, Ohio.
Secretary-Treasurer, Clarence W. Sutton, Central High School, Cleveland.

Eastern Association of Physics Teachers.

President, George A. Cowen, W. Roxbury High School, Jamaica Plain, Mass.
Vice-President, Irving O. Palmer, Newton High School, Newtonville, Mass.
Secretary, Fred R. Miller, English High School, Boston, Mass.
Treasurer, Arthur H. Berry, Classical High School, Providence, R. I.

Natural Science Association. A section of the Ontario Educational Association.

Hon. President, T. L. Walker, Toronto, Ont.
President, T. H. Lennox, Stratford, Ont.
Vice-President, S. B. McCready, London, Ont.
Secretary-Treasurer, E. L. Hill, Guelph, Ont.

Mathematical and Physical Section of the Ontario Education Association.

Hon. President, J. C. McLennan, University of Toronto.
President, W. J. Robertson, Collegiate Institute, St. Catherines.
Vice-President, C. A. Chant, University of Toronto.
Secretary-Treasurer, H. S. Robertson, Collegiate Institute, Stratford.

Indiana Science Teachers' Association.

President, George C. Bush, Marion.
Vice-President, Miss Frances Branaman, Seymour.
Secretary, W. T. H. Howe, Indianapolis.
Treasurer, J. J. Thompson, Richmond.

American Physical Society.

President, Carl Barus, Brown University, Providence, R. I.
Secretary, Ernest Merritt, Cornell University, Ithaca, N. Y.

(Continued on page viii of the Advertising Section)

MATHEMATICAL ANNOUNCEMENT AND REQUEST.

On the occasion of the annual meeting of the American Mathematical Society, an informal conference was held in New York, December 30, 1904, at which were present representatives of a number of associations of teachers of mathematics. The following resolutions were adopted:

Resolved: That each association of teachers of mathematics be requested to send three delegates and as many other members as possible to a conference of representatives of all such associations, to be held in Asbury Park at the time of the meeting of the National Educational Association (July 3-7, 1905).

Resolved: That this conference be requested to consider all common interests of the various associations, and in general, such questions connected with the teaching of elementary mathematics in the United States as here follow.

(*a*) As to the desirability and means of effecting closer permanent relations among the associations.

(*b*) As to the desirability and means of organizing a national association or council of teachers of mathematics.

(*c*) As to the establishment and support of a journal devoted to the pedagogy of mathematics.

(*d*) As to the desirability and means of promoting the formation of new associations of teachers of mathematics.

(*e*) As to relations with associations of teachers of natural sciences.

(*f*) As to the desirability and means of establishing relations with the National Educational Association.

Your association is hereby cordially invited to take part in this conference, which will be held under the auspices of the N. E. A., on July 5, at 10:30 in Asbury Park (Parlor of the First Presbyterian Church).

(Signed) ARTHUR SCHULTZE,
Secretary of Preliminary Conference.

The mathematical editor is authorized, urgently, to request all associations of teachers of mathematics of America to send representatives to this conference whether they receive other special invitation than this or not.

G. W. MYERS.

SCIENCE COURSES IN THE UNIVERSITY OF ILLINOIS SUMMER SCHOOL.

The science courses in the Summer Session of the University of Illinois for the year 1905 will offer unusual opportunities to high school teachers of science who wish to do either elementary or advanced work in Botany, Chemistry, Physics, Physiography or Zoology. The courses are so arranged that the student may take up elementary work in a science with which he is not familiar, or may do advanced work in subjects in which he has had some training. Some courses have been arranged with especial attention to methods of presentation, and most of the courses are so planned that they will count with credit toward a bachelor's or a master's degree. All of the laboratories and libraries open to students during the other terms will be open to summer students; there will be no curtailment of opportunities of any kind.

THOMAS ARKLE CLARKE,
Director.

Urbana, Illinois.